CHEMICAL & METALLURGICAL ENGINEERING

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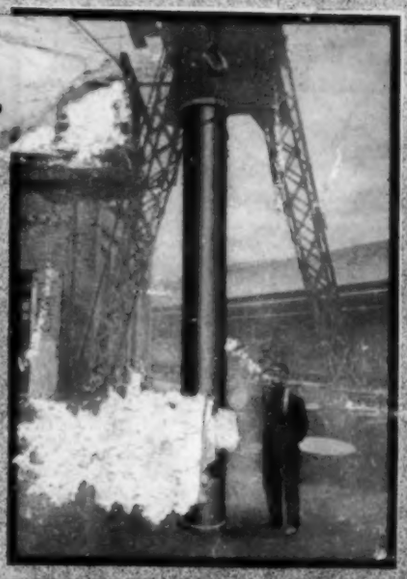

CALITE TUBE 13' 6" LONG, 18" DIA., 1" WALL

CHEMICAL & METALLURGICAL ENGINEERING

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Unemployment and The Cost of Production

AN EXCEPTIONALLY prominent chemical manufacturer made a statement a few days ago that bears repeating, for it directs our thought along some of the less frequented byways of industry. The theme of the discussion was the inefficiency of present-day labor, and to carry his point this manufacturer related an incident that occurred a year ago in one of his chemical plants. During the month of December that plant produced a certain chemical at a cost of, say, $10 per ton. In the following month, with the same workmen receiving the same wages and working the same number of hours, the plant had an increased output of this chemical and the cost of production had dropped to $7.50 per ton. The only new factor entering into the situation was that all during the month of January there had been an ever-increasing crowd outside the factory gate, whereas in the preceding month the plant's employment bureau had been forced to take the initiative in obtaining even a few necessary replacements. In other words, the potential competition of those men outside the gate and the fear of being replaced by lower-priced men had the effect of stimulating the workers to increased production and greater efficiency.

But not long ago a famous British manufacturer, who is also a large employer, visited this country and, among other things, outlined a program of suggested reforms in relations between employer and employee. These he maintained were essential to material progress and represented the only real solution to the problem of industrial unrest. Prominent among his recommendations was the appeal to remove the menace of unemployment and the feeling of economic insecurity which is widely prevalent among the workers.

At first blush it would appear that the actual demonstration in the American factory disproved this part of the Englishman's theory. But is this the case after all? The possibility of unemployment served as a temporary stimulus to increased efficiency in this chemical plant, but are there not other more constructive ways by which this could have been accomplished? For instance, one of the outstanding features in the British manufacturer's program was the suggestion that the worker should have some tangible interest in the results of his labor and that where practicable he should share directly in the profits of the business. Another arrangement which has worked out satisfactorily in some plants is the periodical bonus based on production. In fact anything which tends to promote a closer understanding and a more intimate relation between the men inside the gate and their employer is in the interest of greater output and increased efficiency.

There will always be shirkers and inefficient workmen to retard progress and slow up production, but the future holds much in store for the far-sighted manufacturer who succeeds in convincing the men inside the gate that all are working toward a common goal and that their mutual success or failure is entirely dependent on the combined efforts of the employer and the employed.

Are Colleges Over-Supplying Chemists?

OF ALL the laws of economics the dabbler in the subject usually unversed in business is most familiar with that governing the supply and demand of commodities. Having as a rule only a hazy idea of modern industry and no comprehension of how this law is dependent on many others, he proceeds glibly to generalize on "supply and demand" in relation to professional knowledge also. This forces him to consider the chemist or engineer as an inanimate thing without free choice, without "time-binding" or even "space-binding" characteristics, and immediately leads to a discussion of unionism, licensing or other methods of tampering with these laws.

The man of brains and technical training must in his very soul resent being classed as one of a number. If he's worth his salt he sincerely desires to be different and better, to remain the individual—not one of a class. He abhors the idea of unionizing and licensing.

Now, if we are to discuss an over-supply of chemists, thinking of the chemist purely as a laboratory worker, which unfortunately is the popular conception, such an over-supply does exist and always will exist. For the laboratory worker is merely on the first rung of the ladder. He parallels the draftsman in the engineering field and the test-shop man in the electrical field. Men are turned out of our technical courses and naturally are forced to crowd around the first step.

But industry needs these apprentices badly, and the chemical industry above all others requires more men with chemical training who can be absorbed in the many departments outside the laboratory. As these chemists become operating men, engineers, salesmen and executives, the industry is bettered and the economic return to the individual is, therefore, greatly increased.

Industry will accept them as theorists, but demands of them the ability to grasp the business side. There is no time in a four-year course to make business men of chemists, and it should therefore not be attempted. However, our teaching staffs may help the situation by putting the student in the proper frame of mind to see this aspect and talk less of fundamental research.

The electrical, mining and metallurgical industries have progressed rapidly because of their absorption of highly trained men in every branch of the work. Many hundreds of men are received from the colleges and turned to fit their places in these industries every year. Electrical teaching staffs do not prattle of research. No

more need the chemistry professors. The process industries are fearfully short of the type of technically trained man willing to seize opportunity in all branches.

Wouldn't it be better if our colleges held out a vision of science applied to industry, leaving research to the occasional brilliant mind that shows special adaptability? Industry can still absorb a large number of chemists of varied abilities.

Limiting the Activities Of Trade Associations

"NOW watch for the trade associations to fade away into nothing," was the comment offered by a close observer after the United States Supreme Court had rendered its decision on Dec. 19 in the case of the American Hardwood Manufacturers Association. In effect this association is told that the maintenance of open-price information is practically a restraint of trade and an effort to stifle competition and fix prices. On this ground the Supreme Court ruled that such practices must be discontinued.

For some time there has been little doubt in the minds of close students of association affairs that the open-price agreement would sooner or later be condemned; now the condemnation comes from the highest tribunal of the land and in no uncertain language. The decision will, of course, not at all affect scientific and technical societies that deal with matters of research and investigation or with matters of resource or manufacturing procedure. However, it will vitally affect those industrial groups that attempt to influence trade or commercial practices. In fact it should prove of considerable importance in guiding the activities of the newly organized Synthetic Organic Chemical Manufacturers Association.

Two association activities now distinctly in disrepute in Washington are "lobbying" and "open-price" agreements. There is much splendid work that can be done without dangerous intrusion upon these two fields of endeavor, and there is no doubt that the newly formed chemical organization can accomplish many helpful results. The chemical industry, because of its rapid growth and unnatural development, has failed to lay the proper stress on modern methods of cost finding, merchandising and other business problems on which a trade association might be expected to offer constructive criticism and advice. The study of foreign competition and of market possibilities at home and abroad is also a legitimate activity for co-operative work. Furthermore, there is a definite need for a unified organization to represent the chemical industry in its contact with the Department of Commerce, the Tariff Commission and other governmental agencies. The Bureau of Foreign and Domestic Commerce, under Mr. HOOVER'S guidance, is offering valuable assistance to industries that are willing to pledge whole-hearted co-operation. Can the chemical industry afford to stand aloof?

These are but a few of the many activities that are open to an association in the chemical industry. However, it is not unseemly, perhaps, to sound warning that the decision just rendered by the Supreme Court has placed one very definite limitation on the co-operative work which industry may legitimately undertake through the medium of the trade association. To ignore this decision will not only embarrass the association but will also damage any cause, however worthy it may be, which the industry hopes to serve.

Coke Byproduct Output Misinterpreted

THE GREAT decrease in output of coke during the past twelve months as compared with the large production of 1917, 1918 and 1920 has given rise to some confusion as to the effect upon production of byproducts. The cause for this confusion is easily understood; for those who have examined only totals of coke production have apparently forgotten that these totals do not indicate at all clearly the byproduct part of the business. In fact they are very misleading with respect to byproducts such as ammonia, tar and light oil, for the greater part of the fluctuation in coke totals is caused by the variation in beehive output, which, of course, does not at all affect the byproduct part of the business.

The peak of coke production was reached in 1918, when an average of slightly over 4,700,000 net tons of byproduct and beehive coke was made per month. Following the close of the war, there was a distinct falling off in the total, so that in 1919 the monthly average was over a million tons less than during the previous year, but most of this decrease was on beehive coke, the decrease on byproduct coke output being less than 4 per cent. The following year there was an increase in both beehive and byproduct output, but it was only slight for beehive and very marked in the case of byproduct. As a consequence of this, in 1920 the monthly average beehive coke production was less than two-thirds that of 1917, whereas the byproduct coke production for the same year was the greatest in the history of the industry.

During the present calendar year there have been, of course, large decreases of output of both kinds of coke, and only during the last few months has there been a tendency to increase again toward "normal." However, in no case has the byproduct coke output fallen below 50 per cent of the monthly average production for the previous year, which, as mentioned above, was the greatest ever recorded. The latest figures, those for November, 1921, show about 70 per cent of the monthly average production of 1920. During the same period, however, the output of beehive coke was less than 30 per cent of the 1920 monthly average and less than 20 per cent of the 1917 monthly average.

It is inconceivable that coke ovens should be operated without production of byproducts in more or less fixed ratio to the coke produced. In other words, for every million tons of coke made we can expect substantially uniform output of tar, ammonium sulphate and light oil. whether this million tons of coke be made during a season of great activity or during a period of slack operation. The ratio, of course, is not exactly the same, for different coking periods affect the output of each of the byproducts somewhat; but the ratio for practical purposes is nearly enough uniform to permit us safely to draw conclusions as to these secondary products. It is clear, therefore, that no one is justified in assuming that the byproduct output—tar, light oil and ammonium sulphate—will fall in the neighborhood of 25 or 30 per cent of last year's production, as some seem to think would be the case. The output probably will be in the neighborhood of 65 or 70 per cent of the 1920 totals, for the byproduct coke output of the period will probably be of this order of magnitude. The proper interpretation of these facts is of great importance to the industries which depend upon the coke-oven operations of the country for their raw materials.

Work and Employment in 1920

EXAMPLES of "how not to do it" are generally considered very useful. They are informing, while they do not circumscribe initiative as do examples of how to do it. We have already learned much from the year 1920 as to how not to do it, and now comes the preliminary report of the Bureau of the Census on gainful employment in 1920 to add to this knowledge.

We find from this report that we have some things to unlearn. A very popular idea has been that in 1920 a great many persons were receiving emoluments, including salaries and something called by the undignified and almost opprobrious title of wages, and that the chief thing wrong was that a great many were not working hard for the emolument received. Even that, however, was not the case, for the census report shows that a smaller percentage of the population was engaged in gainful occupation in 1920 than in 1910. There had been an increase in the proportion in each census up to and including that of 1910, but the 1920 proportion is almost precisely the same as that for 1900. The proportion is figured not against the total population but against the population ten years and more of age. The percentages have been: 1880, 47.3; 1890, 49.2; 1900, 50.2; 1910, 53.3; 1920, 50.3. So there is another good story gone wrong. Not as many were holding jobs, not to speak of working.

The Bureau of the Census in its preliminary report intimates that a considerable part of the apparent decrease in the proportion may arise from the 1910 census having been on April 15 while the 1920 census was of January 1, whereby the shown decrease in farm laborers might be accounted for. The common talk, however, was that men had gone away from the farm and got jobs in town, and furthermore it is to be noted that the larger decrease from 1910 to 1920 was in females.

The matter of females in employment is another thing suggesting we have something to unlearn. Most of us have heard so much about females replacing males in employment right along, and particularly on account of the war, that it has been difficult to avoid concluding that the contention must be correct. Not so, according to the census figures. Of the females ten years of age and over 23.4 per cent were gainfully employed in 1910 and 21.1 per cent in 1920, while of the males of the same age the proportions were 81.3 per cent in 1910 and 78.2 per cent in 1920. Thus the female proportion decreased 10 per cent and the male proportion only 4 per cent.

There was nothing particularly startling about industrial conditions on April 15, 1910, when the previous census was taken. We were going along and tending to business. We were not extremely or abnormally active, and 53.3 per cent of the male population ten years of age and over was gainfully employed. January 1, 1920, the proportion was only 50.3 per cent. In addition to a great many who were "gainfully employed" but were loafing more or less in this gainful employment (the census did not attempt to report how much real work they were doing), it now appears that there were a good many who ought to have been working and who did not even have jobs, presumably because they did not want to have jobs. The total number gainfully employed was 8,549,399 females and 33,059,793 males, or 41,609,192 altogether. Now and then there is a little talk—fortunately it shows a tendency to increase in volume—about the "rights of the public" in labor disputes, the unions having a total membership of say 5,000,000 or less. When "the public" is mentioned in this connection it does not mean simply those who do not work, but includes the more than 35,000,000 persons who are gainfully employed but do not seek to get the gain by striking and threatening to strike.

Wildcats in Western Texas

ONE of the outstanding national problems is the gradual impoverishment of the soil. Continuing our present agricultural practices will be to court serious economic difficulties; the problem of fertilization must be solved. Continued impoverishment of the soil will cause us to depend for our exports more and more upon the irreplaceable mineral resources available in limited quantities and less and less upon those foodstuffs which are annually renewed.

It is of more than passing interest, therefore, to study the possibilities of development in this country of natural potash supplies of all types. In every case where there appears reasonable ground for belief that potash deposits occur no time should be lost in exploration to determine their presence, their extent and their workability. Until some commanding percentage of our annual need can be supplied from domestic sources, we can never feel entirely safe against excessive charges by the producers who control the German and Alsatian supplies.

In this issue Professor UDDEN gives illuminating information regarding the possibilities of potash in Texas. He urges, and quite properly, exploration to determine the thickness and the extent of potash-bearing beds which are known to exist at least in small areas and in thin layers at widely separated regions in his state.

In Professor UDDEN'S recommendation, the U. S. Geological Survey also heartily concurs. But the Survey also issues a warning that should be carefully heeded. In a recent announcement given wide circulation, it said:

> To protect the public from misrepresentation and fraud by unscrupulous promoters and sellers of stocks based on potash deposits in western Texas the United States Geological Survey, Department of the Interior, states that the potash deposits there, instead of being 1,100 or even 300 ft. thick, as represented by the promoters, have not yet been proved to be of workable thickness or of commercial value. Rich potash salts, comprising the mineral polyhalite, which were deposited in association with great thicknesses of rock salt and gypsum in "red beds," as in Germany, and, in fact, at the same time as the German deposits, have been discovered by representatives of the United States Geological Survey and the Texas University Bureau of Geology and Technology in a co-operative search, but though this discovery, which was made public early in June, is encouraging and interesting, the practical question whether the deposits are thick enough to mine—that is, whether they are worth anything—is yet to be answered.

There is ample ground for optimism and certain need for exploration to give us exact information. But this is no time for the typical broadcast promotion of stock such as that which has been undertaken by certain persons obviously serving their own interest, not that of the general public. It should be the effort of technical men upon every appropriate occasion to encourage these scientific projects recommended by state and federal authorities; but they will also do a public service if they will repeat the warning which the Geological Survey has issued.

Hardness of High-Speed Steel

Hardness of High-Speed Tool Steel at Moderate Temperatures, Hardness in the Cold After Various Heat-Treatments, and Cutting Efficiency Determined in an Effort to Predetermine the Usefulness of a Modern Machine Tool

BY A. H. D'ARCAMBAL
Metallurgist, Pratt & Whitney Co., Hartford, Conn.

IT IS interesting to read the hardening recommendations for high-speed steel given in the different tool steel catalogs. Some manufacturers recommend an extremely high quenching temperature, with no subsequent tempering; others advocate a high quenching temperature with 400 to 600 deg. F. (204 to 316 deg. C.) drawing heat; a few recommend drawing to 1,050 to 1,100 deg. F. (566 to 593 deg. C.) after quenching from a high temperature; still others advise a lower quenching temperature; one or two recommend pack hardening or salt bath hardening; while one catalog states that drawing to 900 deg. F. (482 deg. C.) in an oil bath produces beneficial results.

In tests just completed by the writer on the best-known brands of high-speed steel made in this country and abroad, the analyses of which are shown in Table I, every brand of tungsten high-speed steel responded in the highest degree to a high quenching temperature followed by a draw at 1,100 deg. F. (593 deg. C.). The treatment recommended by Taylor and White in 1900 was to quench from a temperature close to the fusing point of the steel into a lead bath at 1,150 deg. F. (621 deg. C.), from there into oil or air quench, then drawing to 1,150 deg. F. (621 deg. C.). In the last 20 years the barium chloride process has been proposed, but is now little used, pack hardening was tried and still finds extensive use, especially abroad, and lead-bath hardening was tried and found wanting. Today, therefore, the majority of high-speed steel is being hardened in practically the same manner as recommended by Taylor and White in the beginning.

I have already stated briefly the advantages and disadvantages of the different hardening methods in an article entitled "Various Methods for Hardening High-Speed Steel"[1]. This contribution will attempt to show, by micrographs, hardness data, physical tests and cutting tests, the results produced by different hardening treatments on crucible and electric furnace high-speed steels of various compositions.

Fifteen bars (4¼ in. rounds) listed in Table I were available. Steels numbered 1, 2, 5, 6, 7, 10, 12, 14 and 15 were selected for microscopic examinations, scleroscope tests, cutting tests, etc. As indicated in this table, some of these brands were the product of the crucible furnace, the remainder being electric furnace melted. Brinell hardness varied from 217 to 286; as a matter of fact, high-speed rounds of this size should be annealed to a Brinell hardness not greater than 240, but it seems to be the practice of some mills to conduct this final annealing operation in the shortest time possible, in consequence sending out a product not fully annealed. The majority of American tool steel mills rough turn their larger sized rounds, which is of considerable advantage to the consumer, since a smaller machining tolerance may be used after the scale and decarburized surface have been removed. It also insures bars free from surface defects, for seams or laps are easily detected after turning. Not a bar of several received from abroad was rough turned.

Figs. 1 to 4 show the micrographs of this material as received in the annealed condition. Longitudinal sections were examined in order to reveal carbide segregations, envelope structure, etc. The only specimen showing complete freedom from these defects was No. 14, shown in Fig. 2. It was cut from a disk forged from No. 15 bar. The segregations and large carbide areas shown in Fig. 1 were completely broken up by this added working. Cutters made from hammered disks have greater cutting efficiency than cutters machined from the bar from which these disks were forged, as will be shown later. Bar 5 shows the worst segregation. Massive carbide areas and envelope structures cannot be broken up to any extent whatsoever by hardening; in fact, the only possible way to eliminate this undesirable structure is by further mechanical working.

Each of the bars of high-speed steel was machined into 4 x ⅝ x 1 in. hole, side-milling cutters. Blanks ⅝ in. thick were also cut from these bars; these blanks were then cut into disks, twelve of which were given the semi-muffle furnace treatment, twelve more the barium chloride treatment and the remaining twelve were hardened by the pack process.[2] These pieces were then drawn to different temperatures, carefully ground to remove

[1] CHEM. & MET. ENG., vol. 25, No. 25, p. 1150, Dec. 21, 1921.

[2] For details of this treatment see "Various Methods for Hardening High-Speed Steel," by A. H. d'Arcambal, CHEM. & MET. ENG., vol. 25, No. 25, p. 1150, Dec. 21, 1921.

FIG. 1. STEEL NO. 15; LONGITUDINAL SECTION; × 500

TABLE I. HIGH-SPEED STEELS USED IN TEST

No.	C	Mn	P	S	Si	Cr	V	W	Co	Mo	Brinell Hardness	Method of Mfg.
* 1	0.70	0.18	0.017	0.025	0.13	3.53	0.68	17.56	....	....	286	Cruc. melted
* 2	0.67	0.30	0.016	0.009	0.11	3.66	0.95	17.39	....	....	241	Cruc. melted
3	0.65	0.16	0.022	0.025	0.24	4.70	1.02	18.45	....	....	228	Elec. fce. melted
* 4	0.64	0.24	0.017	0.025	0.16	3.33	1.01	18.44	....	....	228	Cruc. melted
5	0.70	0.18	0.026	0.024	0.41	4.43	....	.....	5.25	4.90	255	Cruc. melted
* 6	0.68	0.30	0.014	0.010	0.22	3.68	0.97	17.51	3.27	....	286	Elec. fce. melted
7	0.70	0.21	0.020	0.025	0.31	4.45	1.18	12.65	....	....	241	Elec. fce. melted
8	0.67	0.14	0.020	0.020	0.23	3.37	0.97	19.05	....	....	217	Cruc. melted
10	0.62	0.22	0.017	0.009	0.14	4.14	0.26	17.84	....	....	269	Elec. fce. melted
11	0.63	0.34	0.024	0.022	0.15	3.89	0.85	18.60	....	....	241	Cruc. melted
*12	0.80	0.25	0.024	0.014	0.14	3.57	1.75	14.70	....	....	228	Cruc. melted
14	0.62	0.34	0.014	0.023	0.09	3.74	0.55	17.87	....	....	217	Cruc. melted, blank forged
*15	0.62	0.34	0.014	0.023	0.09	3.74	0.55	17.87	....	....	217	Cruc. melted
16	1.07	0.32	.....	.....	....	....	....	.....	....	....	...	

* Indicates that bars are rough turned.

scale and decarburized material. A type "D" (dial reading) Shore scleroscope was used to determine the hardness of each sample, the scleroscope readings shown in Table II being the average of not less than ten readings. These results give the following information:

1. The three different methods of hardening all give about the same initial scleroscope hardness.

2. The majority of the samples quenched from the highest temperature (that is, Quenching *A*, the semi-muffle furnace treatment) showed a lower scleroscope reading after drawing to temperatures ranging from 600 to 1,000 deg. F. (316 to 538 deg. C.), but the samples drawn from 1,050 to 1,150 deg. F. (566 to 621 deg. C.) and in some cases as high as 1,200 deg. F. (649 deg. C.) showed the same or greater scleroscope hardness than in the undrawn condition.

3. Samples given the barium chloride and pack hardening treatments (*B* and *C*) also showed a lower scleroscope reading when drawn from 600 to 1,000 deg. F. (316 to 538 deg. C.) than in the undrawn condition. In a few cases the same scleroscope hardness as when quenched was obtained on samples drawn to 1,050 or 1,100 deg. F. (566 or 593 deg. C.). The falling off in scleroscope hardness after this temperature was passed was much greater in every case than found on samples treated in the semi-muffle furnace (Quenching *A*). The highest degree of secondary hardness was therefore obtained in test specimens quenched from the highest temperature.

TABLE II. SCLEROSCOPE HARDNESS OF ½-IN. DISKS OF 4½-IN. HIGH-SPEED STEEL BARS AFTER VARIOUS HEAT-TREATMENTS

Bar	Quenching (See Note)	Drawing Temperature, Deg. F. None	400	600	800	900	1,000	1,050	1,100	1,150	1,200	1,250	1,300
1	*A*	90	90	84	85	84	83	86	90	...	92	87	79
1	*B*	92	92	87	82	82	83	86	87	83	82	82	72
1	*C*	90	92	83	84	84	80	86	82	77	77	72	66
2	*A*	93	92	...	85	86	89	88	92	92	89	86	79
2	*B*	92	91	85	84	84	84	86	91	85	82	76	72
2	*C*	90	91	82	80	82	85	82	82	80	77	72	59
2	*D*	92	...	92	93	...	92	...	93	92	...	...	...
5	*A*	85	88	85	86	87	90	95	96	99	97	94	...
5	*B*	87	86	85	81	82	86	86	93	93	93	86	72
5	*C*	91	91	84	85	86	88	90	95	82	82	74	60
6	*A*	92	93	86	85	90	91	91	91	92	91	86	77
6	*B*	92	90	84	83	83	83	87	92	85	83	77	71
6	*C*	87	85	84	85	79	79	85	76	76	74	72	61
10	*A*	91	91	83	85	83	85	87	89	89	...	78	72
10	*B*	90	90	85	83	82	80	83	88	82	75	70	64
10	*C*	93	90	82	86	80	80	80	83	79	85	67	62
12	*A*	93	92	86	86	86	89	89	91	94	92	88	83
12	*B*	91	91	82	84	83	80	85	88	87	78	75	70
12	*C*	89	91	83	83	83	84	83	88	78	76	73	63

NOTE.—Heat-treatment *A*: Heated to 2,300 deg. F. (1,260 deg. C.) in open fire and quenched in oil at 100 deg. F. (38 deg. C.).

Heat-Treatment *B*: Heated in barium chloride bath for twelve minutes at 2,100 deg. F. (1,150 deg. C.), and quenched in oil at 100 deg. F. (38 deg. C.).

Heat-Treatment *C*: Heated two hours in charcoal pack at 2,050 deg. F. (1,120 deg. C.)—requiring 3 hours to come to heat—and quenched in oil at 100 deg. F. (38 deg. C.).

Heat-Treatment *D*: Heated to 2,300 deg. F. (1,260 deg. C.) in open fire; quenched; drawn to 1,150 deg.; redrawn to various temperatures.

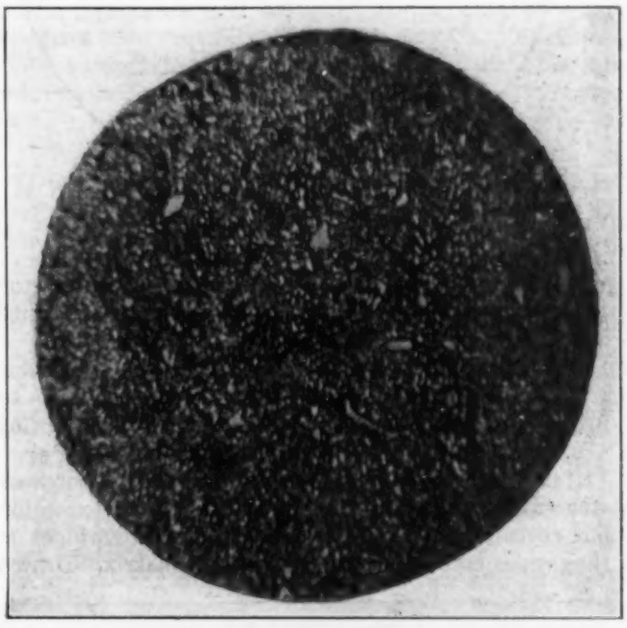


FIG. 2. STEEL NO. 14; FORGED DISK, HAMMERED FROM BAR NO. 15 AND ANNEALED. LONGITUDINAL SECTION; × 500

One of the samples that had been quenched from 2,300 deg. F. (1,260 deg. C.) and drawn to 1,150 deg. F. (621 deg. C.) was redrawn to temperatures up to 1,150 deg. F. (621 deg. C.), giving the results shown in Table II, Quenching 2-*D*. This shows that the scleroscope hardness obtained on redrawing a piece of hardened high-speed steel, which had been drawn to 1,150 deg. F. (621 deg. C.), would be a straight line, instead of showing a softened range from 600 deg. F. (316 deg. C.) to 1,000 deg. F. (538 deg. C.). Greater stability is thus produced by the high drawing treatment.

Microscopic sections were then cut from quenched specimens A, not drawn as well as after drawing to 1,100 deg. F. (593 deg. C.). These micrographs after etching for 2 minutes in a 5 per cent nital solution were then compared with micro-specimens of the corresponding pieces that had received the barium chloride treatment *B*. Fig. 4 shows these micrographs. A close study brings out the following points:

1. A high quenching temperature dissolves nearly all the carbides and tungstides[3] which are not in massive or

[3]Honda and Murakami, "Notes on the Structural Constitution, Hardening and Tempering of High-Speed Steel Containing Chromium and Tungsten" (*Journal of Iron and Steel Institute*, No. 1, 1920), think that the fine white globules visible in high-speed steel under the microscope are a tungstide (Fe_2W) instead of a carbide for the following reasons: 1. The globules have the same behavior with chemical reagents as the tungstide found in carbonless iron-tungsten alloys. 2. Steels containing a definite quantity of carbon and chromium show an increase in these fine globules as the tungsten content is increased. 3. In steels containing a definite quantity of tungsten and chromium the globules do not increase with increasing carbon.

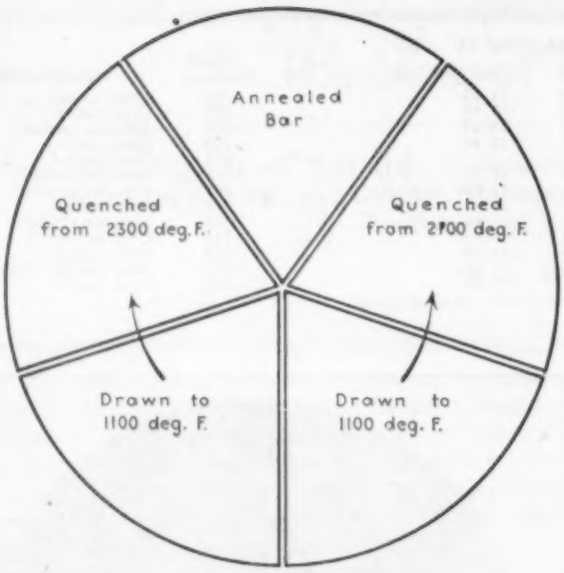


FIG. 3. KEY TO FIG. 4

envelope formation, producing a polyhedral structure; the resulting microconstituents are austenite, martensite and free carbides and tungstides.

2. Drawing to 1,100 deg. F. (593 deg. C.) produces a full martensitic structure and in general with suppression of the polyhedral crystals boundary markings.

3. High-speed steel quenched from 2,100 deg. F. (1,149 deg. C.) or lower does not possess the polyhedral structure of austenite (steel No. 5 being the exception), but reveals considerable quantity of free carbides and tungstides embedded in a martensitic matrix. Drawing to 1,100 deg. F. (593 deg. C.) produces a slight amount of troostite.

4. Severe carbide segregations present in the annealed condition are not dissolved by the hardening treatment.

A comparison of the scleroscope data in Table II with these microstructures indicates that the greatest degree of secondary hardness is attained when the quenched material is partially austenitic. In other words, the higher the quenching temperature the greater the secondary hardening effect. The resistance to tempering is also dependent on the quantity of dissolved carbides.

Quenching high-speed steel from 2,300 deg. F. (1,260 deg. C.) apparently preserves austenite to only a slight degree, for the scleroscope hardness is about the same as for high-speed steel quenched from lower temperatures, which in turn produces a full martensitic structure. Hardened high-speed steel in the so-called "austenitic condition" is also quite strongly magnetic showing that the structure is by no means exclusively austenite. A sample of Mushet steel previously described,[4] quenched from 2,200 deg. F. (1,204 deg. C.) was almost entirely austenitic, for the specimen was non-magnetic and possessed a scleroscope hardness of only 53.

Hardness at High Temperatures

One often hears the question asked "How hard is high-speed steel at a dull red heat?"

In order to determine the hardness of hardened high-speed steels at temperatures from 400 to 1,200 deg. F. (204 to 649 deg. C.), tests were conducted as follows: Disks $\frac{5}{8}$ in. thick were cut from the $4\frac{1}{4}$-in. round bars of high-speed steel as well as from a bar of carbon tool

[4] See CHEM. & MET. ENG., vol. 25, No. 23, p. 1055, Dec. 7, 1921.

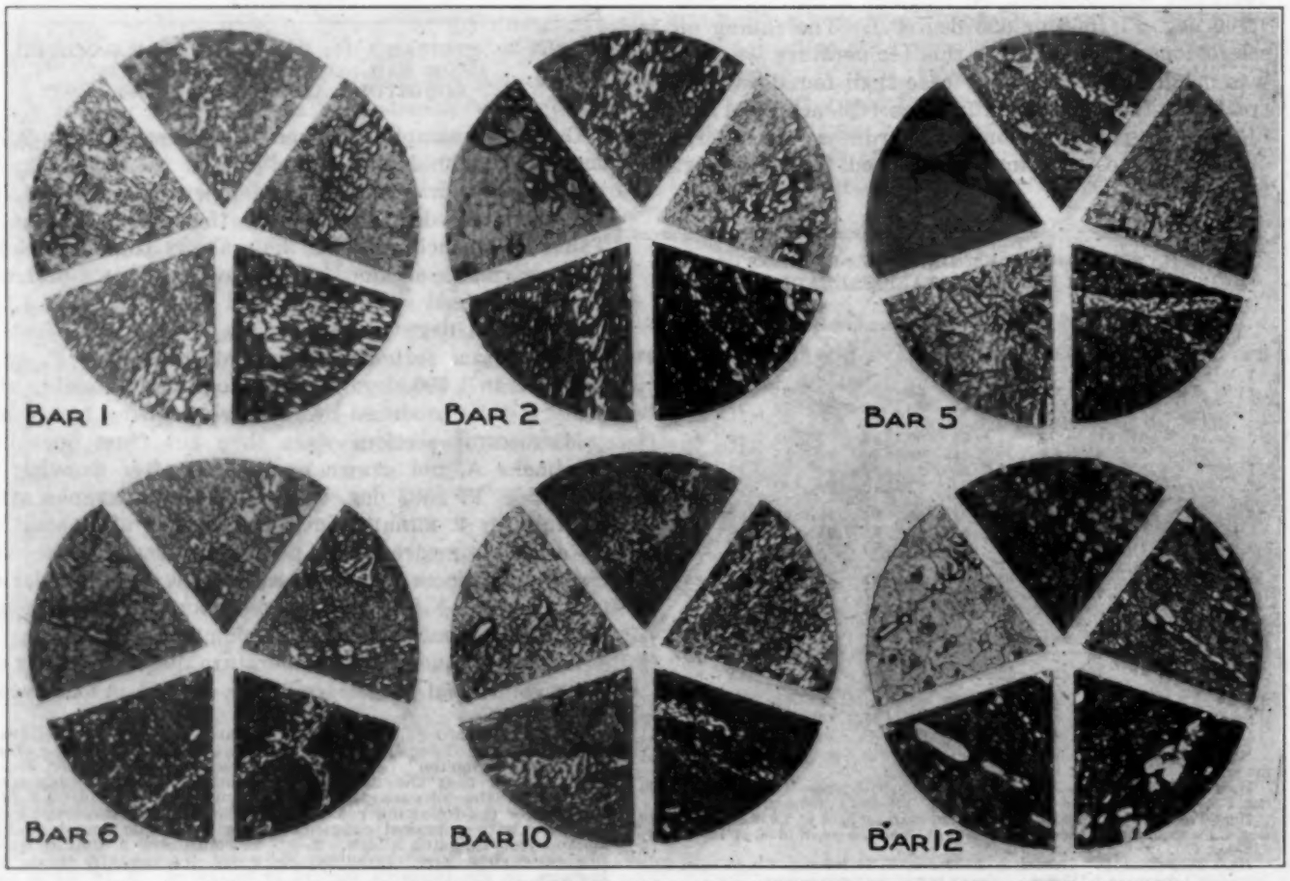


FIG. 4. MICROSTRUCTURE OF VARIOUS HIGH-SPEED STEELS AS RECEIVED AND AFTER VARIOUS HEAT-TREATMENTS. ETCHED 2 MIN. IN NITAL. × 350.

steel, the disks then being halved. These disks were given the hardening treatments shown in Table III and tested for Brinell hardness at room temperature. They were then heated in a small electric muffle furnace, two at a time, with a pyrometer between the disks and touching them. The pieces were held at the desired temperature for a sufficient length of time to insure thorough soaking, removed from the furnace, placed at once on a steel block at the same temperature, and the Brinell hardness taken. The Brinell impressions were scaled immediately and the disk again placed in the furnace for the next higher temperature. After the test at 1,200 deg. F. (649 deg. C.) was taken, the pieces were cooled to room temperature and again tested.

It is necessary to use a ball after each test at 800 deg. F. (427 deg. C.) and higher as the ball was softened

TABLE III. BRINELL HARDNESS OF A HIGH-SPEED TOOL AT ELEVATED TEMPERATURES

			Brinell Hardness							
Bar	Quenching (See Note)	After Quenching	At 400 Deg. F.	At 600 Deg. F.	At 800 Deg. F.	At 900 Deg. F.	At 1,000 Deg. F.	At 1,100 Deg. F.	At 1,200 Deg. F.	After Cooling From 1,200 Deg. F.
1	*E*	652	652	600	532	477	444	418	387	652
1	*F*	652	652	578	512	460	444	387	321	555
2	*G*	652	652	555	512	495	477	418	...	...
2	*H*	652	652	600	555	555	477	418	...	...
5	*E*	600	512	495	444	444	460	418	340	652
5	*F*	627	512	477	444	444	418	387	340	652
6	*E*	652	627	600	532	512	512	444	387	652
6	*F*	652	600	555	512	477	444	418	321	555
7	*E*	652	600	555	495	477	444	418	364	652
7	*F*	652	600	532	460	444	418	375	302	555
12	*E*	652	652	555	512	512	477	418	418	652
12	*F*	652	600	512	512	477	444	340	332	578
16	*I*	713	600	477	302	241	179	...	...	...

NOTE.—Heat-Treatment *E*: Heated to 2,350 deg. F. (1,290 deg. C.) in open fire; quenched in oil at 100 deg. F. (38 deg. C.).
Heat-Treatment *F*: Heated 1½ hours in charcoal pack at 2,050 deg. F. (1,120 deg. C.), (requiring 4 hours to come to heat), and quenched in oil at 100 deg. F. (38 deg. C.).
Heat-Treatment *G*: Same as *E*, except quenching followed by draw to 450 deg. F. (232 deg. C.).
Heat-Treatment *H*: Same as *E*, except quenching followed by draw to 1,100 deg. F. (593 deg. C.).
Heat-Treatment *I*: Heated to 1,480 deg. F. (805 deg. C.) for 10 minutes in lead bath and quenched into brine.

to a slight extent at the contact surface. In no case, however, did the balls flatten when in contact with the hot metal.

The following information is obtained from the data in Table III:

1. The higher the quenching temperature given the different brands of high-speed steel the greater the hardness at temperatures from 600 to 1,200 deg. F. (316 to 649 deg. C.).

2. The cobalt-molybdenum steel No. 5 shows considerably lower hardness at 600 to 900 deg. F. (316 to 482 deg. C.) than do the tungsten steels.

3. High-speed steel quenched and drawn to 1,100 deg. F. (593 deg. C.) (heat-treatment *H*) shows a greater Brinell hardness at temperatures from 600 to 900 deg. F. (316 to 482 deg. C.) than when quenched from the same temperature but only drawn to 450 deg. F. (232 deg. C.) (heat-treatment *G*).

4. All the high-speed steels given heat-treatment *E* (quenched from 2,300 deg. F.) have the same Brinell hardness, with one exception, at 1,100 deg. F. (593 deg. C.).

5. Hardened high-speed steel, while not as hard as hardened carbon tool steel, possesses almost three times the Brinell hardness of carbon tool steel at a dull red heat; see line 16-*I*.

6. High-speed steel disks given the high quench (treatment *E*), drawn to 1,200 deg. F. (649 deg. C.) and cooled gave the same Brinell readings as obtained before drawing. The disks given the pack treatment (*F*), and then drawn to 1,200 deg. F. (649 deg. C.), cooled and tested showed a softening of up to one hundred points. These results would be expected after studying the scleroscope data in Table II.

These Brinell tests at high temperature were a little disappointing in the results obtained, as the steel which showed the greatest cutting efficiency (No. 12) did not show a higher Brinell hardness at the different temperatures than some of the other brands. The steel which showed the poorest cutting qualities (No. 5), however, did show lower hardness at elevated temperatures.

Cutter Tests

It was decided to use heat-treated chromium-nickel steel, S.A.E. No. 3140, for testing these cutters. This alloy steel was given the same heat-treatment as this grade of material usually receives when used for airplane and automobile parts, and the resultant Brinell hardness varied from 262 to 277, the majority of the bars testing 269.

Chemical and physical properties follow:

Analysis	Per Cent	Physical Tests (Standard 0.505-In. Test-Piece)
Carbon.....	0.46	Elastic limit, 112,000 lb. per sq.in.
Manganese...	0.60	Tensile strength, 126,000 lb. per sq.in.
Chromium....	0.69	Elongation, 20 per cent.
Nickel.....	1.16	Reduction of area, 54 per cent.
		Brinell hardness, 269.

These 16 x 2½ x 1⅝-in slabs were ground on all sides after heat-treating to remove scale.

When milling material of this analysis and hardness, it was not necessary to run at such high speeds, feeds and depths of cut to break the tool down as when milling ordinary machinery steel or cast iron. Therefore the following was used: Speed, 130 ft. per minute; feed, 3⅛ in. per minute; cut, ⅛ in. deep; coolant, oil. An examination of each of these cutters showed that the cutting edges were worn, not burned down after being tested.

Referring to Table IV, it will be noted that all of these cutters were quenched from the semi-muffle furnace when they had attained a temperature of 2,300 deg. F. (1,260 deg. C.). They were carefully preheated at 1,600 deg. F. (871 deg. C.) before being placed in the high-speed furnace. The proper time to be given these cutters in the furnaces was obtained by independent experiments, then all the cutters were hardened in exactly the same manner.

Cutters tempered at 450 deg. F. (232 deg. C.) were drawn in an oil bath while cutters given the high drawing treatment (1,100 to 593 deg. C.) were first drawn in the oil bath to 600 deg. F. (316 deg. C.), then transferred to the niter bath at 650 deg. F. (343 deg. C.), and the temperature increased to 1,100 deg. F. (593 deg. C.). The cutters were permitted to remain for 10 minutes at this temperature, then were oil quenched. Cutters quenched from 2,300 deg. F. (1,260 deg. C.) into the niter bath at 1,100 deg. F. (593 deg. C.) were held in the bath for about 4 minutes, then oil quenched. As niter at this temperature attacks high-speed steel when quenched into the same and held for a considerable length of time, a lead bath is more suitable for the quenching medium.

Referring again to Table IV, it will be noted that

TABLE IV. CUTTER TESTS

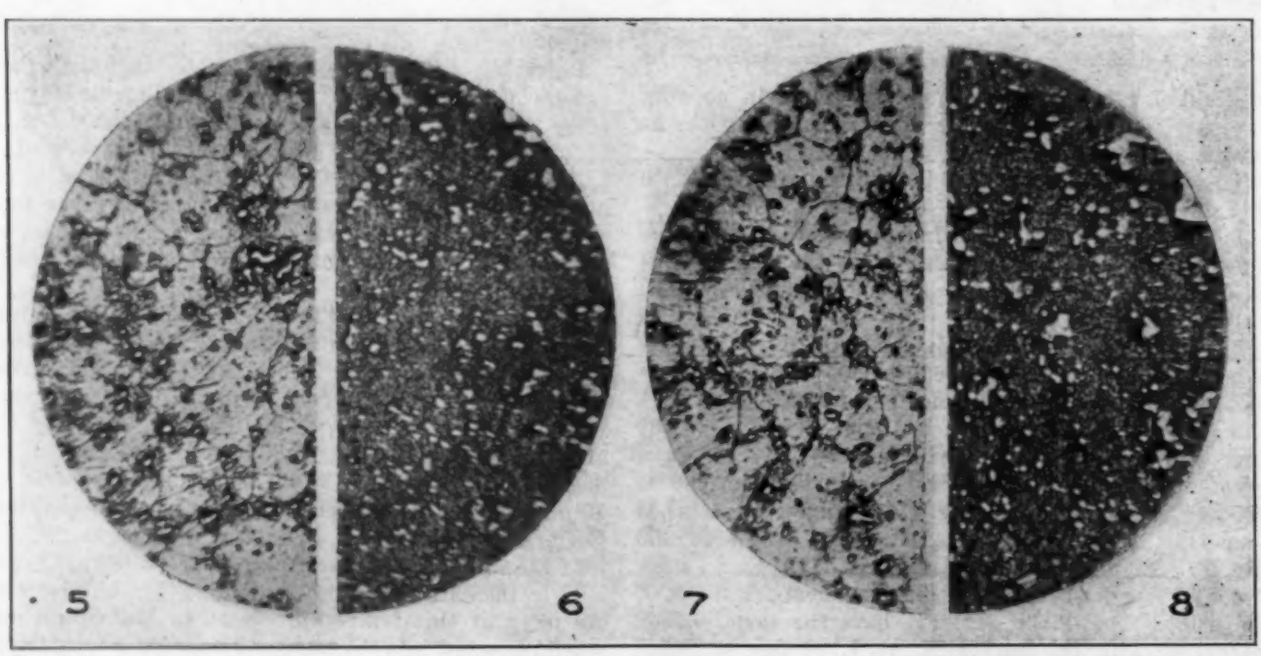
Steel No.	Heat-Treatment	Inches of Metal Cut
12	2,300 deg. F. muffle furnace, oil quenched, 450 deg. F. draw....	132
12	2,300 deg. F. muffle furnace, oil quenched, 1,100 deg. F. draw..	214
12	Average	173
6	2,300 deg. F. muffle furnace, oil quenched, 450 deg. F. draw....	107
6	2,300 deg. F. muffle furnace, oil quenched, 1,100 deg. F. draw..	183
6	Average	145
10	2,300 deg. F. muffle furnace, oil quenched, 450 deg. F. draw....	67
10	2,300 deg. F. muffle furnace, oil quenched, 1,100 deg. F. draw..	216
10	Average	142
7	2,300 deg. F. muffle furnace, oil quenched, 450 deg. F. draw....	88
7	2,300 deg. F. muffle furnace, oil quenched, 1,100 deg. F. draw..	155
7	Average	122
1	2,300 deg. F. muffle furnace, oil quenched, 450 deg. F. draw....	60
1	2,300 deg. F. muffle furnace, oil quenched, 1,100 deg. F. draw..	140
1	Average	100
5	2,300 deg. F. muffle furnace, oil quenched, 450 deg. F. draw....	12
5	2,300 deg. F. muffle furnace, oil quenched, 1,100 deg. F. draw..	65
5	Average	39
14*	2,300 deg. F. muffle furnace, oil quenched, 450 deg. F. draw....	88
14	2,300 deg. F. muffle furnace, oil quenched, 1,100 deg. F. draw..	168
14	Average	128
15	2,300 deg. F. muffle furnace, oil quenched, 450 deg. F. draw....	48
15	2,300 deg. F. muffle furnace, oil quenched, 1,100 deg. F. draw..	155
15	Average	102
2	2,300 deg. F. muffle furnace, oil quenched, 450 deg. F. draw....	59
2	2,300 deg. F. muffle furnace, oil quenched, 1,100 deg. F. draw..	182
2	Average	121
2	2,300 deg. F. muffle furnace, oil quenched, 800 deg. F. draw....	...
	Average	54
2	2,300 deg. F. muffle furnace, quenched in niter at 1,100 deg. F., not drawn	...
	Average	111

*Cutters made from forged blanks using No. 15 bar.

cutters containing somewhat higher vanadium (No. 12) showed the greatest cutting efficiency. The corners on these cutters were in good condition after the test, failure being due to the dullness. In passing it should be noted that each figure in the table represents the average length of cut made by two tools. In nearly all of the other cutters, the corners failed as well as the cutting edges. Steel No. 6, containing 3 per cent cobalt, ranked second, while the cobalt-molybdenum steel No. 5 showed the poorest cutting qualities. Cutters made from this brand of steel were given a higher quenching temperature than recommended by the manufacturer, but it was decided to harden all of these cutters in exactly the same manner. Cutters No. 14, made from forged disks, showed about 25 per cent greater cutting efficiency than those machined from bar No. 15, from which the former were forged. Cutters No. 2, drawn to 800 deg. F. (427 deg. C.), which is in a soft range, as shown by Table II, showed less cutting ability than those made from the same bar, quenched from the same temperature but drawn only to 450 deg. F. (232 deg. C.). Other No. 2 cutters quenched into a niter bath at 1,100 deg. F. (593 deg. C.) performed about twice as well as those drawn to 450 deg. F. (232 deg. C.), but only a little more than half as well as when given the 1,100 deg. F. (593 deg. C.) draw.

One of the important points brought out by these cutter tests was the great increase in cutting properties produced by the high drawing temperature. The results obtained from cutters made of forged blanks, as compared with those machined from the hammered bar, verified the well-known fact that high-speed steel which has received sufficient working to break up carbide segregations and massive carbide areas will produce better tools than material containing them. As stated previously, these crystals will not go into solution on heating for hardening, and as the red-hardness and cutting efficiency are dependent on the dispersion of these carbides and tungstides, the greater cutting efficiency obtained from materials free from these segregations is accounted for.

Another interesting point brought out was the result obtained from cutters No. 2, quenched into a bath at 1,100 deg. F. (593 deg. C.) cooled from that temperature to room temperature and not drawn. The writer has been informed by two or three persons that quenching high-speed steel into a bath of 1,100 to 1,200 deg. F. (593 to 649 deg. C.) produces the same effect as oil quenching and drawing back to 1,100 to 1,200 deg. F. (593 to 649 deg. C.). As the results obtained in the cutter tests showed this was not true, we com-



FIGS. 5 TO 8. OIL VERSUS LEAD BATH QUENCHING. × 500. ETCHED 3 MIN. IN 5 PER CENT NITAL SOLUTION

Fig. 5—Oil quenched from 2,300 deg. F. Fig. 6—Fig. 5 after drawing to 1,100 deg. F. Fig. 7—Quenched from 2,300 deg. F. into lead at 1,100 deg. F.; held 30 min. and air cooled. Fig. 8—Fig. 7 after drawing to 1,100 deg. F.

pared the microstructure of ¾-in. specimens of a high-speed steel[5] after heat-treatments. The results obtained are shown in Figs. 5 to 8.

The specimen quenched into the lead bath at 1,100 deg. F. (593 deg. C.) and not drawn (Fig. 7) has exactly the same structure as the piece from the same bar quenched into oil and not drawn (Fig. 5). Drawing each of these pieces to 1,100 deg. F. (593 deg. C.) produced a full martensitic structure. It would seem that a temperature lower than 750 deg. F. (400 deg. C.), where a head evolution occurs on slow cooling curves of high-speed steel, must be attained before one can successfully obtain secondary hardening properties by reheating.

Hardness results were:

	Scleroscope Hardness	Brinell Hardness
Specimen oil quenched, but not drawn	93	652
Specimen oil quenched and drawn to 1,100 deg. F. (593 deg C.)	94	652
Specimen lead quenched and not drawn	93	652
Specimen lead quenched and drawn to 1,100 deg. F. (593 deg. C.)	94	652

Physical Tests

A ¾-in. round bar of high-speed steel was cut into 7-in. lengths, the pieces centered and turned to ⅞ in. round. These specimens were then quenched from 2,300 deg. F. (1,260 deg. C.) into an oil bath. Three of these test specimens were then drawn to 450 deg. F. (232 deg. C.) in oil, the remaining three pieces being drawn to 1,100 deg. F. (593 deg. C.). All of these bars were then ground to 0.656 in. and transverse tests[6] conducted on the same, the results running as follows:

	Fiber Stress at Fracture, According to Formula, $p = \frac{sM}{I}$ Lb. per Sq.In.	Deflection. In.
Average of three specimens given the 450 deg. F. (232 deg. C.) draw	221,000	0.08
Average of three specimens, given the 1,100 deg. F. (593 deg. C.) draw	550,000	0.20

As can be seen from these results, the bars given the 1,100 deg. F. (593 deg. C.) drawing temperature required two and a half times the load to fracture them, although the hardness was identical (92). Under the microscope, the polyhedral structure was found to be still present in the material given the lower drawing temperature but the specimen drawn to 1,100 deg. F. (593 deg. C.) shows a martensitic ground mass with carbide globules. The results obtained from these transverse tests show that much greater toughness, with no sacrifice of hardness, is produced by the high draw. This greater toughness accounts to some extent for the increase in cutting efficiency obtained.

Summary

A careful study of the data on hardness, micrographs, cutting tests and physical properties leads to the following conclusions:

1. The greatest degree of secondary hardness and the highest actual red-hardness is obtained in specimens given the highest quenching temperature (2,300 deg. F. or 1,260 deg. C.). The micrographs of the quenched samples show that partial austenization has taken place in the steel given this high quenching temperature, with almost complete solution of the carbides and tungstides not in massive or envelope formation.

2. High-speed steel, quenched from a high temperature (2,300 deg. F. or 1,260 deg. C.) and drawn to 1,100 to 1,150 deg. F. (593 to 621 deg. C.), shows as great scleroscope hardness as in the undrawn condition, sometimes greater. Micrographs show that the small amount of austenite present in the undrawn material has changed to martensite.

Toughness and cutting efficiency have been increased from 100 to 200 per cent by the 1,100 deg. F. (593 deg. C.) draw. Cutters given a high quenching temperature, and drawn to 800 deg. F. (427 deg. C.) fail quicker than when given the 450 deg. F. (232 deg. C.) draw. One is led to expect that quenching from a temperature higher than 2,300 deg. F. (1,260 deg. C.) would give a lower initial hardness because of the formation of a larger amount of austenite. Drawing this material to 1,150 to 1,200 deg. F. (621 to 649 deg. C.) should develop the full martensitic structure with a considerable increase in hardness over that obtained in the undrawn condition. The drawing temperature at which this maximum hardness is reached would be higher than when quenched from the lower temperature, principally due to the greater resistance to tempering brought about by the larger amount of dissolved carbides.

3. High-speed steel quenched into a bath whose temperature is about 1,100 deg. F. (593 deg. C.), then cooled from that temperature to room temperature and not drawn, does not possess the same good properties as when drawn back to 1,100 deg. F. (593 deg. C.) after quenching. In other words, high-speed steel cannot be quenched and drawn in one operation. Taylor, in his experiments conducted 20 years ago at the Bethlehem Steel Co., found that it was necessary to draw his tools to 1,100 to 1,150 deg. F. (593 to 621 deg. C.) after they had been quenched in a bath at about the same temperature.

4. High-speed steel, in the larger size rounds, is very seldom free from segregations of massive carbide. As shown in a previous part of this article, these will not go into solution upon hardening. Tools made of material of this nature are of inferior quality, due to brittleness and deficient red-hardness caused by the large amount of undissolved carbides. Forged cutter blanks, which receive a large amount of working in all directions, are free from these segregations and thus produce better tools.

5. The scleroscope or Brinell hardness of a high-speed steel tool is no indication of its cutting qualities. Some of the cutters which showed the greatest cutting efficiency and some of the cutters which produced very little work showed exactly the same hardness readings. The file test is also a misleading one. A high-speed steel tool may be quite easily filed with a good file, but still do just as good work as a similar tool which is file hard.

In closing, the writer wishes to emphasize the fact that using material of the proper chemical analysis does not insure a good tool. If the steel is not fabricated correctly or if the tools are improperly hardened or ground, a poor product will result. However, a close control of all of these factors does insure a uniformly good product.

Hartford, Conn.

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[5] Analysis: C 0.63, Cr 3.42, V 0.79, W 17.98.

[6] A Tinius Olsen universal machine was used testing bars 7 in. long, resting on V-blocks, 6 in. centers. After a load of 50 lb. was imposed, an Ames indicator was so placed to measure deflection and the dial set at zero. The ordinary beam formula was used for computing fiber stresses, and gives comparable results in such hard materials. The analysis of the bar from which these transverse test-pieces were cut follows:

	Per Cent		Per Cent
Carbon	0.62	Vanadium	1.08
Chromium	3.57	Tungsten	17.82

Vapor Pressure of the System Calcium Chloride-Water*

The Application of Dühring's General Law in an Investigation of the Boiling Points of Aqueous Calcium Chloride Solutions of Various Concentrations and Under Reduced Pressures Affords a Graphic Solution of Some Practical Problems in Vacuum Evaporation

By E. M. BAKER and V. H. WAITE

THIS paper is a report of an investigation of the boiling points of calcium chloride solutions at atmospheric and reduced pressures. The apparatus used for the determinations and the method of making the critical study are those described in a previous paper by the same authors.[1]

Five solutions of the following concentrations were investigated:

(1) 141.3 g. $CaCl_2$ per 100 g. H_2O.
(2) 101.0 g. $CaCl_2$ per 100 g. H_2O.
(3) 68.86 g. $CaCl_2$ per 100 g. H_2O.
(4) 25.91 g. $CaCl_2$ per 100 g. H_2O.
(5) Saturated solution.

The range of pressures over which the boiling points of the system were studied was from 100 mm. to 760 mm. absolute pressure.

Chemically pure calcium chloride was used for these determinations. Solutions were made up of about the concentrations desired, and the boiling-point curves were determined by the method described. In the case of the more dilute solution a sample of this liquor was then poured into a glass-stoppered sample bottle, which was then sealed with paraffin and held for analysis. In the case of the more concentrated solutions this method could not be used, since on cooling the $CaCl_2$ would partly or completely crystallize, often breaking the containing bottle. For these solutions the sample was taken by pouring a portion of the solution, while still hot, into a tared weighing bottle containing a weighed amount of water. The bottle was then weighed, sealed and saved for analysis. The results of the analysis were calculated back to the original concentration of solution. The standard gravimetric method for chlorine, using $AgNO_3$, was used for determining the concentration of the various solutions. The solutions were tested to determine if any HCl had resulted from hydrolysis and had been given off with the vapor. Hydrolysis was found to be negligible. To make an error of 0.1 deg. in the boiling point the concentration as determined would have to be in error by 0.25 g. of calcium chloride per 100 g. of water, at the range where the boiling point changes most rapidly with a given change of concentration.

Procedure for Concentrated Solutions

Work on unsaturated solutions would have been carried to even higher concentrations than was done, if these solutions were not so viscous that there could be no assurance that at higher concentrations they would be of uniform concentration throughout.

In determining the boiling-point curve for the saturated solution it was necessary to immerse the platinum resistance thermometer directly into the solution, as the solution was so extremely viscous that the pumping tube could not be made to work. Except for immersing the bulb of the thermometer in the solution, the method used was the same as for the unsaturated solution. Temperatures were taken both for ascending and descending pressures with an excess of solid $CaCl_2$ in the boiling-point tube in order to eliminate the possibility of supersaturation or undersaturation. The experimental values thus obtained for both the saturated and unsaturated solutions are shown in Table I.

Experimental Values and Those in Literature

Most of the data given in the literature on the boiling points of $CaCl_2$ solutions can be classified into two groups:

(*a*) The boiling temperature of solutions of a given strength at various pressures.

(*b*) The boiling temperature at atmospheric pressure of solutions of different concentrations.

Fig. 1 shows the data of group *a* plotted by the method referred to in the previous article—i.e., for each solution of a given concentration, the temperatures at which the solution has certain vapor pressures are plotted as ordinates, against the corresponding temperatures at which water has the same vapor pressures, as abscissas. It is noticeable that the data given in the literature for boiling points of calcium chloride solutions at reduced pressures do not include solutions more strongly concentrated than 43 g. of $CaCl_2$ per 100 g. of H_2O.

Data taken from the literature are indicated by separate symbols for each worker. It will be noted that many of these values as plotted are erratic and do not fall on the curve. However, this is presumably due to experimental errors, as they do fall more nearly on the straight line curves than on any other smooth curve that could be drawn.

In Fig. 1 are also shown experimental data for the solutions investigated by the authors. The curves are lettered to indicate the concentration of each solution. The values for individual determinations are given in Table I and are shown in the graph by the large open circles. In the discussion of the apparatus in the previous paper it was stated that an absolute accuracy of 0.1 deg. C. could be expected in these determinations. The maximum variation of any of the above points from the straight lines as drawn is 0.1 deg. C., while most of the points do not lie more than 0.02 or 0.03 deg. C. from the respective straight lines.

For each concentration of solution represented in Fig. 1 the boiling temperatures of the solutions corresponding to the pressures at which water would boil at 100 deg. C. and 50 deg. C., were read off—i.e., at

*Read before the Thirteenth Semi-Annual Meeting of the American Institute of Chemical Engineers at Ann Arbor, Mich., on June 21, 1921.

[1] "Boiling Point of Salt Solutions Under Varying Pressures," by E. M. Baker and V. H. Waite, CHEM. & MET. ENG., vol. 25, No. 25, p. 1137, Dec. 21, 1921.

TABLE I. VAPOR PRESSURES OF $CaCl_2$ SOLUTIONS AT VARIOUS TEMPERATURES. EXPERIMENTAL VALUES

Concentration: Grams $CaCl_2$ per 100 g. H_2O									
25.91		68.86		101.00		141.30		Saturated Sol.	
Temp., Deg. C.	Pressure, Mm. Hg	Temp., Deg. C.	Pressure, Mm. Hg	Temp., Deg. C.	Pressure, Mm. Hg	Temp., Deg. C	Pressure, Mm. Hg	Temp., Deg. C.	Pressure, Mm. Hg
58.02	113.3	72.66	115.1	82.10	112.9	90.95	108.7	100.05	118.8
65.90	162.7	80.05	161.0	90.28	162.4	99.00	153.6	105.25	154.6
70.90	203.0	85.20	200.8	95.45	202.6	104.51	193.9	111.90	194.6
76.19	254.2	90.70	251.9	100.85	253.0	110.15	243.7	115.20	219.2
81.00	310.0	95.68	308.8	106.10	311.6	115.42	298.7	118.76	242.9
85.45	370.8	100.37	370.5	110.61	371.3	120.61	362.3	125.58	299.8
90.58	452.7	105.56	451.4	115.90	451.7	126.12	442.4	132.32	363.3
95.24	539.5	110.30	537.7	120.65	537.5	131.20	528.9	139.5	440.1
100.00	641.8	114.96	634.2	125.39	635.4	136.37	632.0	144.55	498.7
103.8	738.6	119.35	738.4	129.88	738.8	140.92	733.5	147.90	536.2
.....	....	.....	.....	.....	.....	.....	.....	152.75	596.8
.....	....	.....	.....	.....	.....	.....	.....	173.4	742.5

760 mm. and 92.3 mm. pressure. From these two readings the slope or tangent of the angle of inclination of each line was calculated. It has been shown that if t_1 and θ_1 are the temperatures at which the solution and pure water will boil under some pressure p_1, and if t_2 and θ_2 are the corresponding temperatures for some pressure p_2, the slope of the line is defined as K in the formula $K = \frac{t_1 - t_2}{\theta_1 - \theta_2}$. These results are tabulated in Table II and shown in Fig. 2.

Explanation of Curves

Fig. 2 shows two curves. In curve *A* the concentration of solution in grams of $CaCl_2$ per 100 g. of H_2O as abscissas is plotted against the slope of the above lines as ordinates. This curve was extrapolated graphically and the extrapolated portion does not possess the same degree of accuracy as the remainder of the curve. However, in preparing Tables III and IV only that part of the curve was used which was determined by experimental data.

Curve *B* shows a plot of concentration of solution as abscissas against the boiling point at one atmosphere pressure as ordinates. In addition to the values obtained from Fig. 1, the values given in the literature for the boiling point of solutions at one atmosphere pressure were also plotted on this curve. Curve *B* is not drawn to pass through a majority of the points as plotted, but the probable relative accuracy of the original data was investigated and after taking into consideration the method of each worker the curve was drawn to pass through the values which are presumably the most nearly correct. It will be noted that the curve is practically determined by our values and those of Johnston[2] and that some values reported in the literature differ widely from the curve.

From the curves of Fig. 2, corresponding values were read for concentration of solutions, boiling point at one atmosphere pressure (boiling point of water 100 deg. C.) and *K*, the slope of the lines. These data, which are tabulated in Table III, completely define the boiling points of unsaturated calcium chloride solutions between the two limits given.

If θ is the temperature at which water has any vapor pressure *P*, and if t is the temperature at which a solution also has the vapor pressure *P*, then $\theta = 100 - \frac{t_1 - t}{K}$, or $t = t_1 - (100 - \theta)\ K$, where *K* is the slope of the line for the solution of the given concentration, and t_1 is the temperature at which this solution would boil

[2]See Bibliography, page 1178.

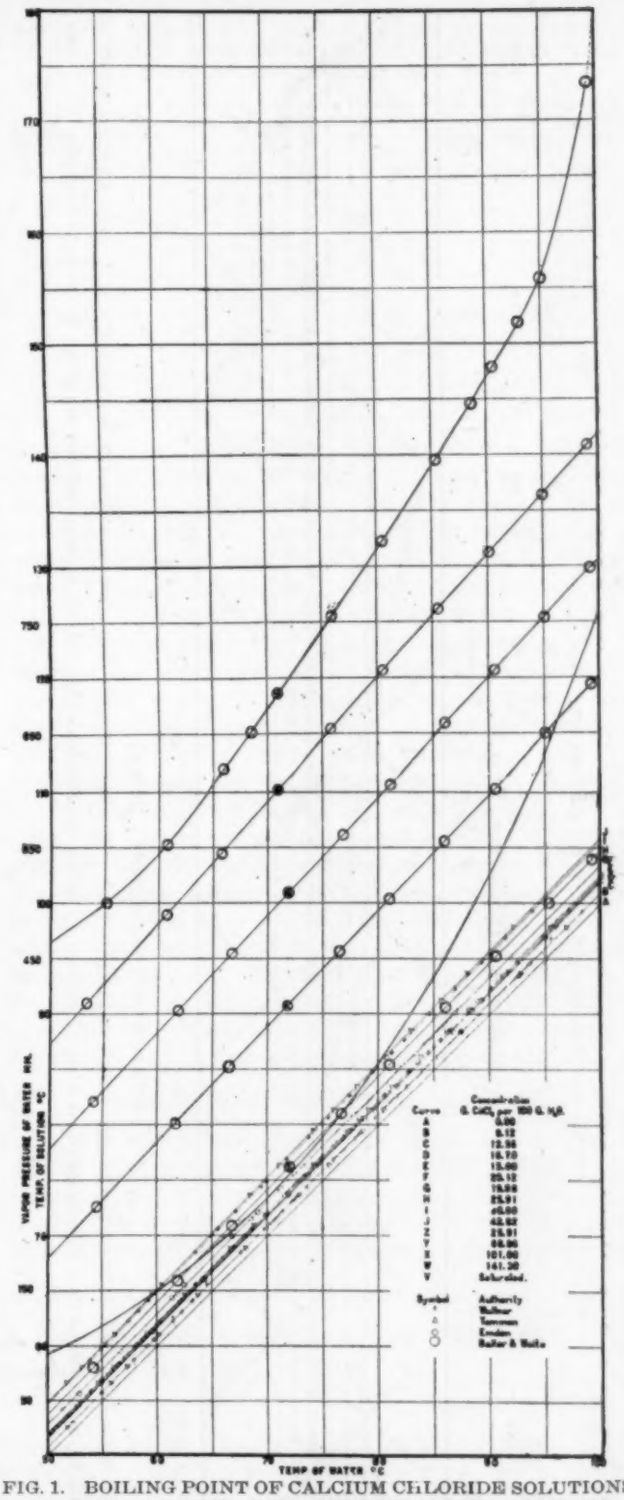

FIG. 1. BOILING POINT OF CALCIUM CHLORIDE SOLUTIONS PLOTTED AGAINST THE CORRESPONDING BOILING POINTS OF WATER UNDER THE SAME PRESSURE

under one atmosphere pressure. Thus if the constants *K* and t_1 are known for the given solution, with the aid of steam tables it is easy to calculate the boiling point of the solution at any pressure. By the use of the above formula, and substituting the respective values of *K* and t_1 for each of the concentrations of solution tabulated in Table III, and 50 deg. for θ, the temperature at which these solutions would boil at 92.3 mm. (boiling point of water 50 deg. C.) were calculated. Fig. 3 was plotted from these data and the boiling points of the solutions at 760 mm. pressure,

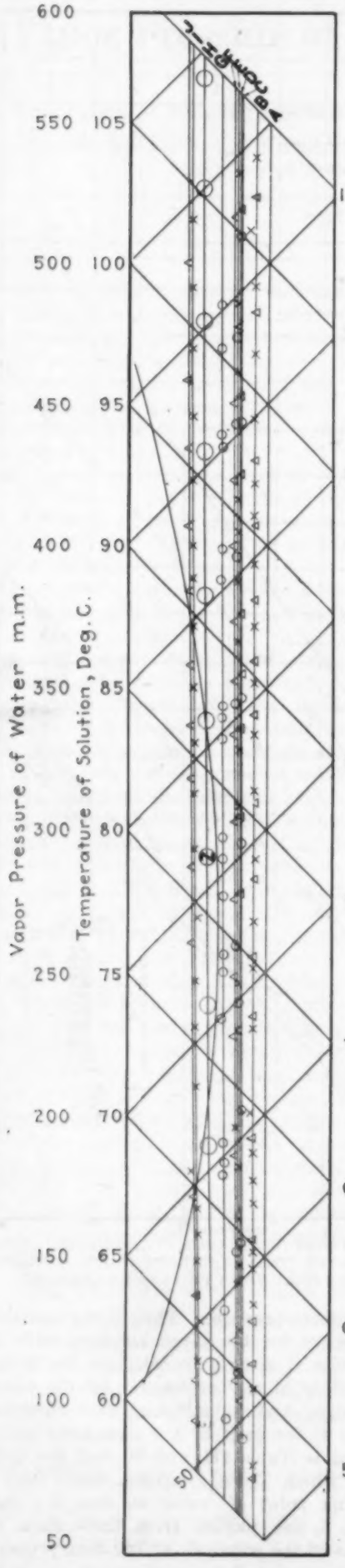

FIG. 1A. BOILING POINTS OF CALCIUM CHLORIDE SOLUTIONS PLOTTED AGAINST THE CORRESPONDING BOILING POINTS OF WATER UNDER THE SAME PRESSURE

Curves A to J from Fig. 1 are here reproduced on a greatly enlarged scale. Explanation of the symbols and data regarding concentration are given in the legend on Fig. 1

TABLE II. RELATION OF CONCENTRATION OF $CaCl_2$ SOLUTIONS TO SLOPE OF CURVES IN FIG. 1, AND TO BOILING POINT AT 760 MM. PRESSURE. VALUES READ FROM FIG. 1

Concentration, in per Cent	Concentration, (Grams $CaCl_2$ per 100 G. H_2O)	Slope $K = \frac{t_1 - t_2}{\theta_1 - \theta_2}$	Bp. at 760 Mm.
20.58	25.91	1.020	104.78
40.78	68.86	1.047	120.18
50.25	101.00	1.058	130.70
58.56	141.30	1.092	141.90

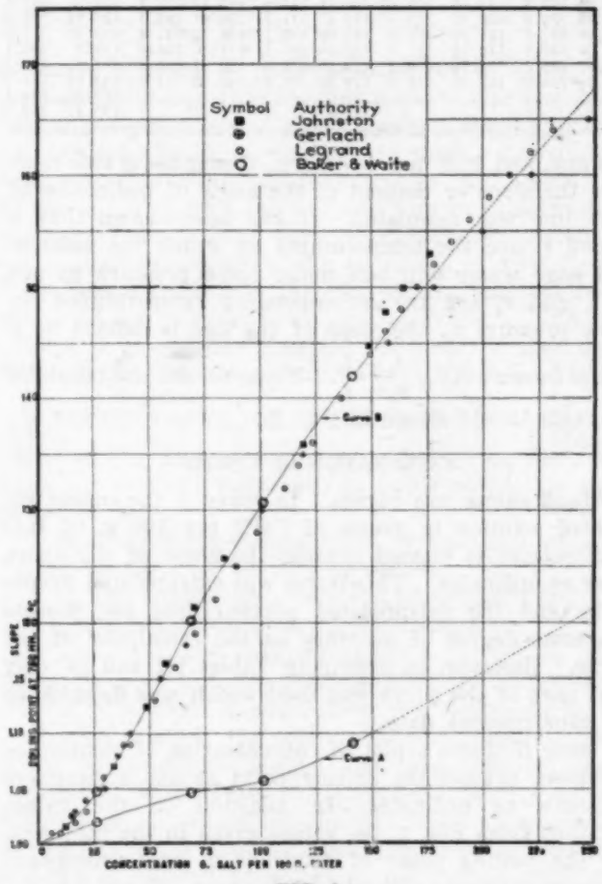

FIG. 2.

Curve *A*. Concentration of solution plotted against slope of lines in Fig. 1. Curve *B*. Concentration of solutions plotted against boiling points of solutions at 760 mm.

the latter data being tabulated in Table III. The ordinates of Fig. 3 show the temperature at which the solutions would boil under some given pressure, plotted against the temperature at which water would boil under the corresponding pressure, as abscissas. For each of the solutions shown, the boiling points at 760 mm. and 92.3 mm. (boiling points of water 100 deg. C. and 50 deg. C.) were plotted, and straight lines were drawn between the two intermediate points. The corresponding curve for the saturated calcium chloride solution was also plotted directly from the experimental data. As here reproduced the scale is too small to permit Fig. 3 being directly used as a source of data, but it may be easily reconstructed on a large scale from the data of Table III. However, numerous values were read from this figure, and these are reproduced in Table IV, which shows the temperature at which calcium chloride solutions of various concentrations would have certain vapor pressures, between the limits of 100 mm. and 760 mm. pressure.

Since the curves *A* and *B* of Fig. 2 are based on comparatively few values determined by us, the same

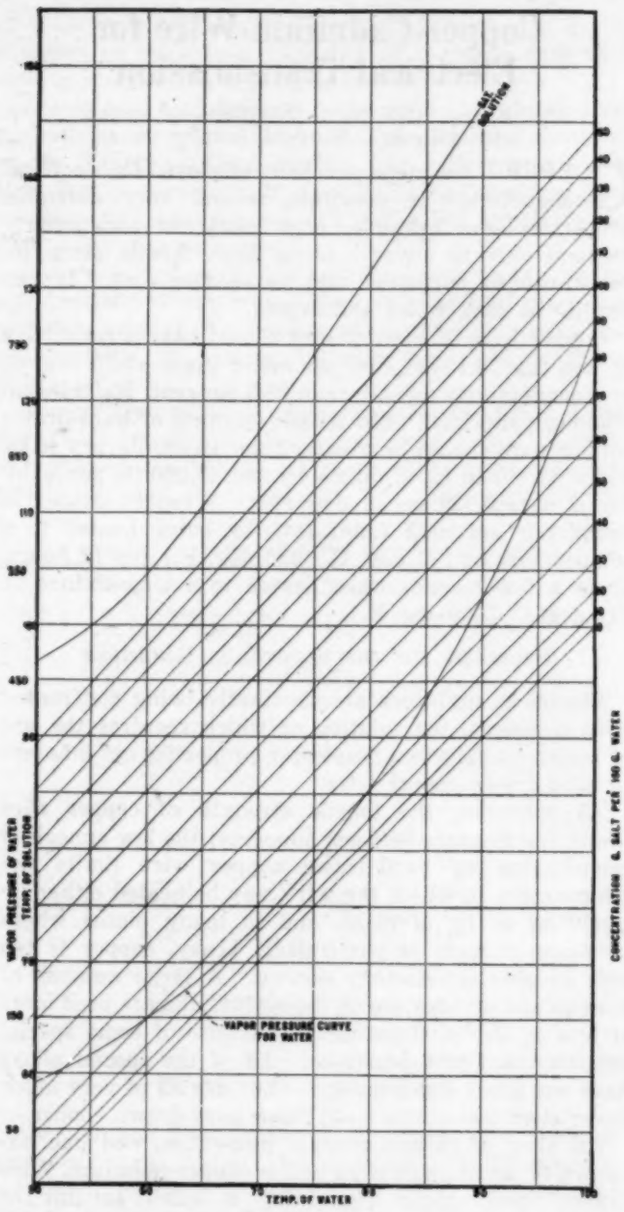

FIG. 3.
Boiling points of calcium chloride solutions plotted against corresponding boiling points of water under the same pressure.

TABLE III. RELATION OF CONCENTRATION OF $CaCl_2$ SOLUTIONS TO BOILING POINT AT 760 MM. PRESSURE AND TO THE SLOPE K. VALUES READ FROM FIG. 2

Concentration (Grams $CaCl_2$ per 100g. H_2O	Slope $K = \frac{t_1 - t_2}{\theta_1 - \theta_2}$	Boiling Point at 760 Mm. (Bp. of H_2O = 100 Deg.	Boiling Point at 92.3 Mm. (Bp. of H_2O = 50 Deg.)
10	1.008	101.30	50.90
20	1.016	103.20	52.40
30	1.023	105.85	54.69
40	1.030	109.25	57.75
50	1.0365	112.90	61.07
60	1.043	116.70	64.55
70	1.0475	120.60	68.22
80	1.0505	124.00	71.47
90	1.053	127.25	74.60
100	1.057	130.35	77.50
110	1.063	133.35	80.20
120	1.0705	136.20	82.67
130	1.080	139.05	85.05
140	1.0905	141.65	87.12
150	1.101	144.20	89.15

accuracy is not claimed for the data on the system as a whole, as tabulated in Table IV, as for an individual determination. The probable maximum error of the latter is 0.1 deg. C., while the corresponding error of values in Table IV may reach 0.2 or 0.3 deg. in extreme cases. An absolute accuracy of this order is quite sufficient for practically all technical purposes.

It will be noticed that the vapor pressure curve of water (data from Peabody's Steam Tables, 1910) is also plotted in Fig. 3. This curve may be used to give directly the vapor pressure under which a given solution will boil at a given temperature and *vice versa*. For instance, to find the vapor pressure corresponding to the boiling point at 90 deg. C. of solution of 100 g. $CaCl_2$ per 100 g. of water, extend across horizontally from 90 deg. on the temperature ordinate to the curve for the given concentration. Then, extending down vertically from this intersection, the temperature at which water would boil at the same pressure is found to be 61.85 deg. C. Or, if the pressure is read corresponding to the intersection of this abscissa with the curve for the vapor pressure of water, this pressure is found to be 162.3 mm. and is the pressure sought.

Solving Some Evaporator Problems

As a second simple illustration of the use of Fig. 3, assume that a calcium chloride solution is being concentrated in a single effect evaporator. Exhaust steam is available at a pressure corresponding to 105 deg. C. The minimum permissible temperature drop across the

TABLE IV. VAPOR PRESSURE OF $CaCl_2$ SOLUTIONS AT VARIOUS TEMPERATURES. VALUES FROM FIG. 3

Vapor Pressure of Solution at temperature T.	Temperature of Solutions Containing G Grams $CaCl_2$ per 100 G. H_2O																Saturated Solution
	$G=0$	$G=10$	$G=20$	$G=30$	$G=40$	$G=50$	$G=60$	$G=70$	$G=80$	$G=90$	$G=100$	$G=110$	$G=120$	$G=130$	$G=140$	$G=150$	
760	100.00	101.30	103.20	105.85	109.25	112.90	116.70	120.60	124.00	127.25	130.35	133.35	136.20	139.05	141.65	144.20	179.5
720	98.50	99.80	101.70	104.32	107.70	111.35	115.12	119.00	122.42	125.69	128.75	131.74	134.60	137.40	140.00	142.51	168.9
680	96.90	98.15	100.05	102.70	106.05	109.70	113.45	117.32	120.75	124.00	127.05	130.00	132.89	135.70	138.29	140.75	162.1
640	95.30	96.50	98.40	101.00	104.38	108.00	111.75	115.60	119.02	122.28	125.35	128.28	131.12	133.92	136.50	138.95	156.6
600	93.50	94.80	96.65	99.25	102.60	106.20	110.00	113.80	117.20	120.50	123.55	126.45	129.30	132.10	134.60	137.10	152.8
560	91.70	92.92	94.78	97.35	100.70	104.30	108.10	111.85	115.30	118.50	121.60	124.50	127.30	130.05	132.60	135.05	149.8
520	89.70	90.98	92.80	95.35	98.70	102.30	106.00	109.82	113.25	116.45	119.52	122.45	125.20	128.00	130.48	132.99	146.3
480	87.60	88.82	90.63	93.20	96.55	100.10	103.80	107.60	111.00	114.20	117.28	120.20	122.95	125.70	128.18	130.60	143.0
440	85.40	86.6	88.40	90.90	94.20	97.75	101.50	105.25	108.65	111.88	114.90	117.80	120.55	123.30	125.75	128.10	139.5
400	83.00	84.15	85.90	88.45	91.70	95.25	98.95	102.75	106.10	109.30	112.35	115.25	117.95	120.65	123.10	125.45	136.0
360	80.30	81.50	83.25	85.75	89.00	92.55	96.20	100.00	103.40	106.55	109.60	112.45	115.15	117.85	120.25	122.60	132.0
320	77.50	78.55	80.30	82.75	86.05	89.55	93.20	96.95	100.35	103.50	106.50	109.35	112.05	114.70	116.10	119.40	127.9
300	75.92	76.95	78.68	81.15	84.40	87.90	91.50	95.30	98.65	101.85	104.85	107.70	110.35	113.00	115.35	117.65	125.6
280	74.35	75.40	77.10	79.55	82.80	86.25	89.90	93.65	97.00	100.20	103.20	106.00	108.65	113.30	113.60	115.90	123.2
260	72.55	73.60	75.28	77.70	81.00	84.40	88.00	91.80	95.10	98.30	101.30	104.10	106.75	109.40	111.65	113.90	120.6
240	70.60	71.70	73.35	75.75	79.00	82.43	86.00	89.80	93.10	96.30	99.30	102.10	104.70	107.30	109.60	111.85	118.1
220	68.60	69.65	71.30	73.70	76.90	80.35	83.95	87.70	91.00	94.20	97.20	100.00	102.60	105.20	107.45	109.65	115.5
200	66.55	67.55	69.20	71.60	74.75	78.15	81.75	85.50	88.80	92.00	95.00	97.75	100.35	102.90	105.15	107.35	112.5
180	64.15	65.15	66.75	69.10	72.30	75.70	79.30	83.00	86.30	89.45	92.40	95.20	97.80	100.35	102.50	104.70	109.5
160	61.60	62.55	64.15	66.50	69.70	73.05	76.65	80.30	83.65	86.75	89.70	92.45	95.05	97.55	99.75	101.90	106.2
140	58.60	59.65	61.20	63.60	66.75	70.05	73.60	77.30	80.60	83.75	86.70	89.45	92.00	94.45	96.60	98.70	103.1
120	55.45	56.35	57.90	60.25	63.35	66.70	70.25	73.90	77.20	80.35	83.35	86.00	88.55	91.00	93.10	95.15	100.2
110	53.65	54.60	56.10	58.40	61.50	64.85	68.35	72.00	75.30	78.45	81.35	84.10	86.60	89.05	91.15	93.15	99.0
1	51.65	52.60	54.10	56.35	59.50	62.80	66.30	70.00	73.25	76.40	79.30	82.00	84.50	86.95	89.00	91.00	97.6

heating surface to give the desired evaporator capacity is 20 deg. C. The evaporator is operated at an absolute pressure of 160 mm. What is the maximum degree to which the concentration of the $CaCl_2$ solution can be carried, and satisfy the above conditions?

From the ordinate of 160 mm. pressure, extend across horizontally to the vapor pressure curve for water, finding that water would boil under this pressure at 61.6 deg. C. Then extending up vertically on this abscissa (61.6 deg. C.) to the ordinate 85 deg. C., the concentration of the solution that would boil at 85 deg. C. under 160 mm. pressure is found by interpolation to be 85.2 g. $CaCl_2$ per 100 g. of H_2O. This is the concentration sought. The actual temperature drop is 105 deg. — 85 deg. = 20 deg. C., while the temperature drop for evaporating water under the given pressures would be 105 deg. — 61.6 deg. = 43.4 deg. C.

Or again, suppose it were desired to carry the concentration to 150 g. of $CaCl_2$ per 100 g. of water, in the above case, what would be the necessary temperature of the steam to have a minimum effective temperature drop of 20 deg. C. across the heating surface when the solution reached this concentration? The absolute pressure in the evaporator is 160 mm. Extending across horizontally from this pressure ordinate to the vapor pressure curve for water, it is found that water will boil at 61.6 deg. C. under this pressure. Extending up vertically from this abscissa of 61.6 deg. C. to the curve for a solution of 150 g. of $CaCl_2$ per 100 g. of water, it is found that this solution would boil under this pressure at 101.9 deg. C. Then to give an effective temperature drop of 20 deg. C., the temperature of the steam would have to be 101.9 deg. + 20 deg. = 121.9 deg. C., or 1580.8 mm. absolute pressure; whereas for evaporating water under like conditions, the steam would have to be under an absolute pressure of only 378.8 mm.

A bibliography of references on the vapor pressure of calcium chloride solutions is appended.

Acknowledgment is made of the financial assistance received from the National Research Council, which made possible this investigation.

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Department of Chemical Engineering,
University of Michigan,
Ann Arbor, Mich.

Favorable African Market for American Products

Vice-Consul John R. Minter of Johannesburg reports in the Nov. 21, 1921, issue of *Commerce Reports* that not more than 3 to 5 per cent of the paints and varnishes consumed in South Africa are manufactured locally. Americans have been holding their own in the South African markets. Imports from the United States in 1914 constituted 28 per cent of the total imports of paints and varnishes, 40 per cent in 1919, and 40 per cent in 1920.

Copper-Cadmium Wire for Electrical Transmission

BY W. C. SMITH
Metallurgist, U. S. Metals Refining Co.

COPPER is the metal generally employed for electrical conductors. It combines several very desirable properties—for example, high electrical conductivity (second only to silver), fairly high tensile strength, resistance to corrosion and reasonable cost. It can readily be cast, rolled and drawn.

Copper wire of good quality should have a resistivity of less than 0.15535 ohm per meter gram at 20 deg. C. or a conductivity greater than 98.5 per cent, Matthiesson standard, annealed. The tensile strength of hard-drawn copper wire should be greater than 49,000 lb. per sq.in. for a wire 0.46 in. in diameter, and 67,000 lb. per sq.in. for a wire 0.040 in. in diameter. Wrought copper is completely softened (annealed) by being heated to a temperature of 175 deg. C. (350 deg. F.) for 72 hours, or in a few seconds when heated to a temperature of 310 deg. C. (600 deg. F.).

PROBLEMS FOR THE ELECTRICAL ENGINEER

Electrical engineers are constantly being confronted with problems, the solution of which requires the use of metallic conductors possessing properties not inherent to hard-drawn copper wire.

As examples, the tensile strength of copper wire limits the distance between supports; the low annealing temperature of hard-drawn copper wire limits the temperature to which the wire may be heated either by intention or by accident, and in many places where abrasion of wear is particularly heavy, copper is too soft to give satisfactory service. A large number of brasses and bronzes are on the market and are used more or less as electrical conductors because of some special property each one possesses. All of the special alloys have one great disadvantage—they are all of very much lower electrical conductivity than hard-drawn copper.

An alloy of rather unusual properties, and one unknown to the average engineer, is copper-cadmium. Wire drawn from copper containing a small amount of cadmium has a much greater tensile strength, is considerably harder, has a higher annealing temperature than a pure copper wire of the same size, and its electrical conductivity has been reduced to a lesser degree than for any other known alloy of equivalent tensile strength.

RESULTS OF LABORATORY TESTS

The results of some laboratory experiments made by the writer during 1918 and 1919 are shown in the accompanying curves of Fig. 1. In every case the wire tested was a No. 12 B. & S. gage (approximately 0.081 in. in diameter). The tensile strength tests were made on hard-drawn wire, and the conductivity tests were made on annealed samples.

Annealing was done by passing 150 amp. through each sample for 65 seconds. Preliminary experiments indicated that a complete anneal could be made under these conditions. A series of laboratory experiments on the annealing temperatures of copper-cadmium wire as compared with pure copper wire indicated that the annealing temperature of the copper-cadmium increased as the cadmium content was increased, and that a wire containing 1.10 per cent cadmium withstood a temperature

of 260 deg. C. (500 deg. F.) for ½ hour, with only slight evidence of softening, while the pure copper wire was *dead soft* after the same treatment.

A hardness test made on a cast alloy containing 1.10 per cent cadmium indicated that the alloy was about 20 to 22 Brinell numbers harder than cast copper. No Brinell tests were made on wire, but it was observed that the alloy wires were somewhat stiffer and harder to file than wires of pure copper.

Mill tests indicated that wirebars containing up to 1.20 per cent cadmium could be hot-rolled, but when the cadmium content of the alloy was further increased the bars cracked in passing through the breaking down rolls.

The melting point of copper is approximately 1,083 deg. C. (1,980 deg. F.), of cadmium 321 deg. C. (609 deg. F.) and the boiling point of cadmium is approximately 778 deg. C. (1,332 deg. F.) This explains the

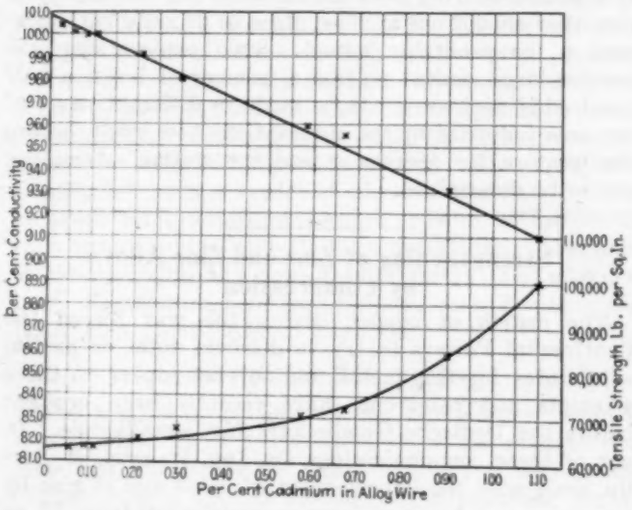


FIG. 1. STRENGTH AND ELECTRICAL CONDUCTIVITY OF COPPER-CADMIUM WIRE

failure of our first attempts to produce an alloy of uniform composition by the direct addition of cadmium to molten copper. Experimental work developed the fact that a uniform alloy could be produced by introducing the cadmium into the molten copper in the form of an alloy of copper and cadmium rich in cadmium. For this work alloys containing from 30 to 75 per cent cadmium have been used. The base alloy generally employed contains about 50 per cent cadmium. It was found that the base alloy could be produced from molten copper and solid cadmium with the loss of very small amounts of cadmium if the temperature were accurately controlled.[1]

A number of lots of copper-cadmium wirebar were made by adding calculated amounts of copper-cadmium base alloy to known quantities of molten refined copper in a large ladle, and then casting the metal into wirebar molds. The wires drawn from the several wirebars of each cast were tested for tensile strength and conductivity. These tests indicated that uniform results could be expected.

Copper-cadmium wire has been successfully used for wireless aërials, long-span transmission wire and trolley wire.

Chrome, N. J.

[1]The method of production of the base alloy and its use to produce copper-cadmium alloy of the desired composition is covered by U. S. Pat. 1,307,642 (June 24, 1919).

On the Discovery of Potash in West Texas

BY J. A. UDDEN
Director of Bureau of Economic Geology, University of Texas, Austin, Texas

FOR some time it has been regarded as quite likely that potash may exist in association with the extensive salt beds underlying the west part of the state of Texas. In 1912 S. M. Swenson & Co. were drilling a deep well at Spur, in Dickens County, and this work seemed to offer an opportunity for making observations bearing on this question. Accordingly it was arranged that the Bureau of Economic Geology and Technology of the University of Texas should be permitted to collect and to make analyses of several samples of brines from this boring. These samples carried evidence of a more than normal amount of potash in the brine only from 2,100 to 2,200 ft. below the surface. An account of this was published on pages 82 to 90 in Bulletin 363 of the University of Texas.

In 1914 an opportunity was likewise presented to secure samples of salt from two borings in Potter County. These showed the presence of a potash-bearing red mineral at several depths. A report on these results was prepared and published in 1915. This was our Bulletin 17, entitled "Potash in the Texas Permian." Largely on the strength of the evidence in these observations, the U. S. Geological Survey undertook to drill a hole at Cliffside in Potter County, to obtain more definite information on the occurrence of potash in the salt beds in that vicinity. Very slight evidence of potash was found also in this exploration, the results of which were published in the potash report of the Survey for 1917. Later co-operation was arranged between our bureau and the U. S. Geological Survey and a man was engaged to get all information possible in the field on the occurrence of potash in association with salt in such wells as were being drilled for oil in the western part of the state. We have now had a co-operative man in the field for 3 years. Lately D. D. Christner, the joint representative of the two Surveys, has found potash in five new places in the Llano Estacado about 200 miles south of the first occurrences noted.

EXTENT OF THE POTASH-BEARING STRATA

The potash-bearing mineral is, in almost every case noted, a red salt, which is now believed to be polyhalite, at least in part. This mineral contains about 18 or 19 per cent of potash. The occurrence of this mineral in sufficient quantity in the drillings taken at considerable depths makes it appear desirable to investigate the size of the deposits. This can be done only by coring the salt beds. As the salt and potash are both soluble in water, the taking of cores through such beds requires special and expensive processes, and to obtain the results desired it should be done under competent scientific and technical direction. The latest five places where potash has been found are about 60 miles apart. It seems possible that the potash-bearing strata may extend the entire distance between these places and possibly up to the Panhandle. From a recent study by N. H. Darton, of the United States Geological Survey, it appears that conditions that may be considered favorable for the natural concentration of salt and also potash in the formations of the Permian, in which these salt beds occur may have been widespread, reaching possibly from western Oklahoma southwestward to the

Pecos River. The largest part of this area lies in our own state.

To summarize the evidence obtained showing the existence of potash in this state the following brief statements can be made:

In 1912 S. M. Swenson's boring at Spur, in Dickens County, gave a brine at 2,200 ft. below the surface, which contained 5.4 per cent of potassium, calculated as chloride.

In 1915 a boring at Boden, in Potter County, furnished some red salt, probably polyhalite, occurring somewhere between 875 and 925 ft. below the surface, and this red salt contained 9.2 per cent of potash, calculated as oxide.

In the same year the Miller boring in Potter County furnished at somewhere between 1,500 and 1,700 ft. below the surface some red salt that contained 6.1 per cent of potash calculated as oxide, and at some level below 1,700 ft. it had some colorless salt associated with anhydrite. This salt contained 10.5 per cent of potash, calculated as oxide.

Within the last 12 months, we have found in the Bryant boring in Midland County, in cuttings accumulated while boring from 2,405 to 2,425 ft. below the surface, a mixture of colorless and red salt, shale and anhydrite yielding 6.9 per cent of potash, calculated as oxide.

We have found in the early part of last spring in the La Mesa Oil & Gas Co.'s Burns No. 1 boring in Dawson County, at a depth of from 1,864 to 1,865 ft. below the surface a red salt which yields 10.8 per cent of potassium oxide.

In the Means well, in Loving County, about 40 miles north of Pecos, samples show 15.5 per cent of potassium oxide, coming from a depth of 1,000 ft., and there is 8 per cent of potassium oxide in samples from between 1,855 and 1,860 ft.

In the River well of the A. Pitts Oil Co., about 8 miles east of Barstow, in Ward County near the Pecos River, showings of 14.4 per cent of potassium oxide were obtained from samples taken at 1,600 ft. In a sample taken at a depth of 1,875 ft. in the same boring there was found 10.5 per cent of potassium oxide.

In the G. A. Jones et al. Long well, in the southeast part of Borden County, an analysis shows the presence of 22.9 per cent of potassium oxide in a picked sample from between 1,070 and 1,075 ft., and a picked sample from cutting between 1,075 and 1,083 ft. showed 17.68 per cent of potassium oxide. The sample from 1,115 ft., similarly picked, shows 6.59 per cent.

Need of Systematic Exploration

It is generally known that the salt beds of our Permian on the High Plains have resulted from concentration of water in the arms of the sea during a long period of time in the Permian age. The desiccation of these waters caused the potash salts of the brines to be precipitated last, whenever the points of saturation for these salts was reached. Evidently desiccation did not go far enough in many cases to precipitate the potash. We can scarcely expect that evaporation of such arms of the sea should continue through a long period of time, resulting in the laying down of a considerable number of salt beds and that desiccation should in every case have stopped short of precipitating the potash. In the many cases of partial or total desiccation indicated by the number of salt beds found in the Permian, it is more likely that the waters were in some cases completely evaporated. Reasoning in this way, there is good ground for the belief that potash should exist in separate beds in that part of our Permian basin where most salt was precipitated. Our finding of potash salts in no less than seven wells, two of which are located in the Panhandle and five in the Llano Estacado, strongly tends to prove the correctness of the conclusion that widespread beds of potash exist in this region; but the observations that have so far been made give absolutely no information on the thickness of the potash-bearing beds. All we know is that there are such beds. To determine the thickness of the beds in order to find whether these deposits will prove of commercial importance, it will, as already stated, be necessary to drill special holes for that purpose and to take out cores of the beds, to be carefully examined. As I look at it, the time is now at hand when our information justifies such explorations. It is scarcely conceivable that potash-bearing beds should occur for 300 miles and that they should not at some place be of sufficient thickness to be profitably mined. Such explorations will require large capital, so that a number of holes, a half hundred if necessary, can be made in different parts of the area indicated by the observations now made, before the location for operations and the method of mining are to be determined.

Austin, Tex.

Strengthening of Zinc and Zinc Alloys by Compression

The dearth of copper during the war forced the Continental Powers to try to discover total or partial substitutes for this metal, and several papers on these attempts and researches have recently been brought before the Deutsche Gesellschaft für Metallkunde. In one of these communications Dr. Ing. Hanszel, of Berlin, deals with the improvement of brass and of zinc by compression. Various brasses containing from 57 to 61 per cent of copper, about 1 per cent of lead and about 3.5 per cent of total impurities were improved by compression after reheating; but they were not sufficiently uniform to be quite reliable. Zinc containing about 1 per cent of lead, with traces of iron and cadmium, was so much strengthened by high compression that it appeared almost a different metal with its grainy, partly fibrous structure. Compression of zinc had been in use in the Hohenlohenhütte, Silesia, before the war. The ingots should be perfect, the tops and pipe must be discarded, and the ingot remelted before compression; cracks in the ingot are not really welded up by compression. When objects like stoppers with threaded bolts are pressed in the molds, sharp corners should be avoided, and the profile rounded off first and finished on the lathe; the zinc flows, and the lines of flow are diverted at sharp corners. The superior qualities of this compressed zinc are, moreover, confined to the temperature range 0 deg. to 50 deg. C., but the metal seems to bear the winter cold well. Storage for several years did not deteriorate several of the alloys of zinc with copper and aluminum, which also passed the repeated gage tests. Among these the alloy of zinc with 6 per cent of copper and 5 per cent of aluminum found favor in Austria and was, later, with only 2.5 per cent of aluminum, manufactured also at Spandau. Zinc alloys with up to 30 per cent of Al were also tried, and the alloys were tested in large quantities, both mechanically and metallographically. These metals and alloys were mainly utilized in ammunition works.

The Electrolytically Produced Calcium-Barium-Lead Alloys Comprising Frary Metal*

Equilibrium Diagram and Microstructure of Barium-Lead and Calcium-Lead Alloys—Ternary Alloy Hardens and Strengthens on Aging; Is Hard at Moderate Temperature; Can Be Melted Without Change in Analysis, and Is a Very Fine Bearing Metal

BY WILLIAM A. COWAN, L. D. SIMPKINS AND G. O. HIERS
National Lead Co. Research Laboratories

DURING the early part of the World War when, on account of the large amount of shrapnel bullets being made from antimonial lead, there was a shortage of this material and of antimony, a substitute was eagerly sought. It was following this that Drs. F. C. Frary and S. N. Temple procured patents[1] covering alloys of lead with barium, calcium and other elements. The calcium-barium-lead alloy was found to have remarkable qualities as a bearing metal, showing the characteristic structure and necessary properties required for such service. The Bureau of Standards[2] made a report of physical and service tests on a submitted sample of the alloy showing better results than with genuine babbitt and stating that it possessed all the requisites of a good bearing metal. The alloy has been manufactured on an extensive scale for this and other uses by the United Lead Co.

METHOD OF PRODUCTION

The method of production can be classified as electrodeposition from fused salts, since the process consists in electrolyzing the fused chlorides of barium and calcium over a bath of molten lead as cathode. In the preparation of alloys of barium and calcium by this method the electrodeposited metals are taken up by the lead, and the resulting alloy is obtained as the desired product.

There has been previous mention made in the literature[3] of similar methods of preparing either pure metals or alloys by electrolysis of fused salts. Such elements as sodium, calcium, magnesium, zinc and aluminum have been prepared as pure metals in this way, the principle involved being essentially the same in all cases, but differing in difficulties encountered. These are owing to differences in melting points and dissociation phenomena of the salts, as well as to differences in the properties of the pure metals produced.

Preparation of metallic calcium from fused calcium chloride has been accomplished only after overcoming numerous difficulties. It was prepared on a fairly large scale during the war, and has also been made experimentally both by the Westinghouse Manufacturing & Electric Co.[4] and by the General Electric Co. However, owing to the difficulties in producing pure metallic calcium free from chlorides, carbides and other impurities, it is not economical to produce an alloy by first preparing the calcium separately and adding it to molten lead. There would also be trouble in commercial manufacture of an alloy by mixing the pure metals in this way owing to the difficulty of obtaining complete solution of the calcium in the lead without loss by oxidation of the calcium. In attempting to produce metallic barium electrolytically it has been found that the resulting barium gathers around the cathode in droplets which fail to coalesce, and therefore it is not economical to attempt to obtain the barium in a pure metallic state. However, with the use of a bath of molten lead as a cathode, this difficulty is not encountered, since the barium alloys readily with the lead as it is produced.

MANUFACTURE

Calcium-barium-lead alloys suitable for bearing metals and other purposes, together with the process of manufacture, are described in United States patents.[5]

FIG. 1. BATTERY OF ELECTROLYTIC POTS FOR MANUFACTURING FRARY METAL; UNITED LEAD CO., KEOKUK, IOWA

The process of manufacture, as carried out by the United Lead Co. operating under these patents, consists in the use of a series of iron pots of about 2 tons capacity each. These are party filled with pig lead of high quality. As shown in Fig. 1, each pot of the series is set in brickwork containing a hearth which is fired with coal. After the pots have been filled with pig lead all the hearths are fired until the lead is melted. On top

*A paper read before the fortieth meeting of the American Electrochemical Society, Lake Placid, Sept. 29, 1921 (slightly condensed).

[1] U. S. Patents 1,158,671-5.

[2] Bureau of Standards, "Report on Tests of Ulco Hard Metal" to National Lead Co., May 6, 1918.

[3] *Trans. Am. Electrochem. Soc.*, vol. 9, p. 123 (1906); vol. 17, p. 249 (1910); vol. 18, p. 117 (1910); vol. 10, p. 63 (1906); vol. 16, p. 185 (1909). MET. & CHEM. ENG., vol. 8, p. 253 (1910). *Z. Elektrochem.*, vol. 8, p. 817, p. 697 (1902). *Electrochemical Industry* (now CHEM. & MET. ENG.), vol. 3, p. 63 (1905); vol. 4, p. 152 (1905). *Transactions Faraday Society*, vol. 2, p. 56 (1906).

[4] "The Electrolytic Production of Calcium," P. H. Brace, *Trans. Am. Electrochem. Soc.*, vol. 37, p. 465; CHEM. & MET. ENG., vol. 25, p. 105, July 20, 1921.

[5] U. S. Patents 1,360,339 (T. F. Wettstein); 1,360,348 (G. H. Worrall); 1,360,272 (E. A. de Campi).

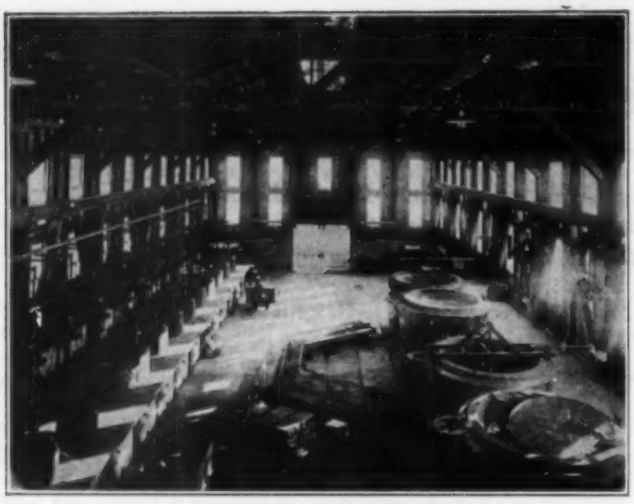


FIG. 2. INTERIOR VIEW, UNITED LEAD CO.'S PLANT FOR FRARY METAL

of the molten lead is placed a layer of the mixed salts of calcium and barium chlorides of high purity, in such proportions as to give a low melting point. This layer of chlorides is usually about 3 or 4 in. thick. Each pot is equipped with a graphite anode at the center which can be raised or lowered by a chainblock.

In starting, the anodes are inserted in the chlorides and a direct current thrown in. There is sufficient resistance in the salts to produce enough heat to fuse the mixed chlorides. The temperatures in the pots are controlled by raising or lowering the anodes. Under the influence of the electrolytic action, the fused salts are decomposed and the resulting calcium and barium are absorbed by the molten lead. There is a tendency toward fogging and arcing, and considerable amounts of the calcium and barium form carbides which reduce the efficiency of the process, therefore requiring approximately 3 days of electrolysis to produce a lead alloy containing 2 per cent of the alkaline earth metals. The fused chlorides and carbides tend to freeze at the surface, forming a hard crust, particularly around the periphery of the interior of the pots. If this forms too near the anode, it may need to be broken down in order to give proper conditions; otherwise it is advantageous, acting as an insulator and thus preventing loss of current which might pass through the fused electrolyte from the anode directly to the iron pot instead of to the molten lead. Absorption of the calcium and barium by the lead appears to follow a logarithmic curve—that is, it requires much longer than 3 days to produce an equal increment of absorption of the alkaline earth metals. This is probably due to an equilibrium set up between the lead and the alkaline earth metal on the one hand, and in the decomposition of and reactions in the fused electrolyte on the other hand.

After the electrodeposition has been under way for some time, samples of the molten metal are removed, and the barium and calcium contents determined, additional samples being taken from time to time until the desired composition is obtained. When the proper amounts of calcium and barium have been absorbed by the lead, the current is shut off and the molten alloy is run out from the bottom of each pot into a carrying ladle of equal capacity, which is conveyed by an overhead crane. By this means the metal from the whole series of pots is emptied into a large mixing kettle shown in Fig. 2, where it is thoroughly agitated and further alloying ingredients are added. The resulting alloy is then sampled and cast in water-cooled ingot molds.

Frary Metal

The alloy thus produced by the United Lead Co. has been termed "Frary metal." As disclosed by the patents, it is essentially a ternary alloy of lead, barium and calcium, with the addition of small amounts of other elements. It contains up to 2 per cent barium and up to 1 per cent calcium, the remainder consisting almost entirely of lead. As much as 0.25 per cent mercury and smaller amounts of other elements may be added.

Metallography

In studying the metallography of the alloy it is most profitable first to consider the binary alloys, barium-lead and calcium-lead. The constitution of the latter series of alloys has been investigated by N. Baar[6] and L. Donski,[7] and a portion of the thermal equilibrium diagram, adjacent to the lead side, as published in Landoldt,[8] is reproduced in Fig. 3.

Several points in the curves have been checked very closely by determinations made at this laboratory. It appears from the complete diagram that additions of

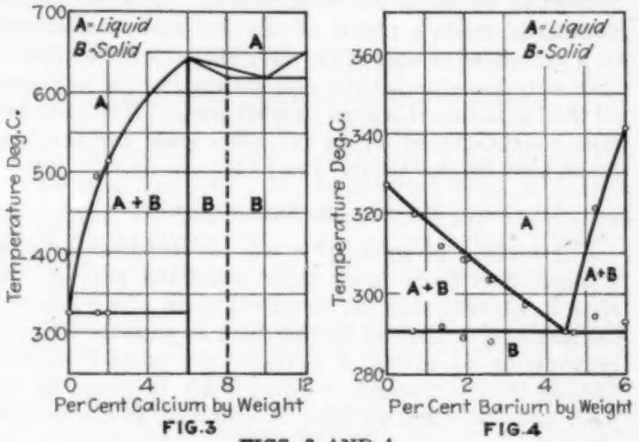


FIG. 3 FIG. 4

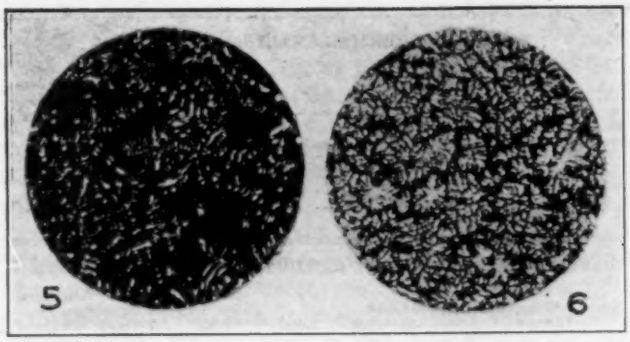
FIGS. 3 AND 4

Fig. 3—Calcium: lead equilibrium diagram, according to Baar and Donski.
Fig. 4—Barium: lead equilibrium diagram, according to Cowan, Simpkins and Hiers.

calcium up to 6 per cent, where the compound Pb_3Ca is formed, raise the melting point rapidly. Other compounds are formed beyond this and the melting point is increased to 1,100 deg. C. The photomicrographs, Figs. 5 and 6, are in accord with this equilibrium diagram. They show crystals of lead-calcium compound Pb_3Ca in a ground-mass of lead. The crystals appear to be rod- or needle-shaped, and at higher magnification the rods are shown to be built up of cubical crystals. (Fig. 10.)

Calcium-lead alloys for experimental purposes were made at this laboratory from pure lead and metallic calcium. The lead is melted in a ladle and heated to about 500 deg. C. A piece of calcium is then held under the molten lead, being scraped meanwhile to remove oxide, etc., and to permit the lead to come in contact with clean metallic calcium. When the calcium dissolves, there is a decided exothermic reaction and more lead in bar form is quickly inserted in the molten metal to cool the alloy and prevent oxidation. In this way alloys containing up to 6 per cent calcium were made up

[6] *Z. anorg. Chem.*, vol. 70, p. 375 (1911).
[7] *Z. anorg. Chem.*, vol. 57, p. 217 (1908).
[8] "Tabellen," Landoldt, Börnstein and Roth; 1912 edition, p. 664.



FIGS. 5 AND 6. MICROSTRUCTURE OF CAST Ca:Pb ALLOYS. NOT ETCHED. × 50. COMPOUND (Pb_3Ca) IN RELIEF IN GROUND MASS OF LEAD

Fig. 5—Ca 1.52 per cent, Pb remainder.
Fig. 6—Ca 3.2 per cent, Pb remainder.

to be used as base metals in preparing other alloys for further investigations.

In studying the constitution of barium-lead alloys no published data could be found.[a] An alloy was produced for us at the plant of the United Lead Co. at Keokuk, Ia., by the electrolytic process from fused barium chloride, using molten lead as cathode. (Table I.) By diluting this with pure lead, alloys of varying compositions were produced for our investigations. Cooling curves were determined both by the differential and the inverse rate methods. From the results obtained the equilibrium diagram shown in Fig. 4 was derived.

TABLE I. COMPOSITION OF CALCIUM USED AND ALLOYS STUDIED

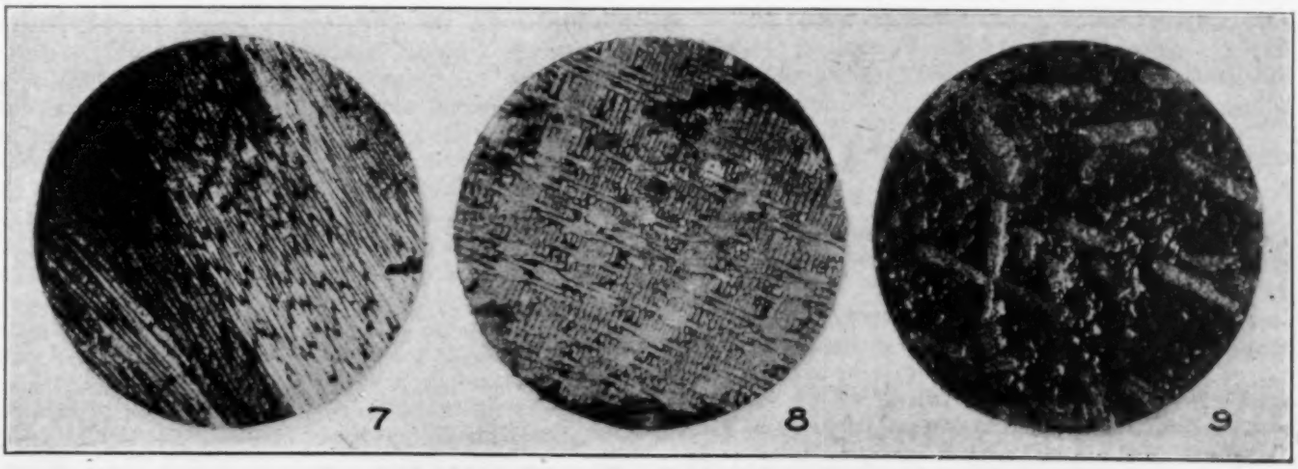
	Electrolytic Calcium from General Electric Co. Per Cent	Calcium-Lead Alloy Made by Authors, Per Cent	Barium-Lead Alloy from United Lead Co., Per Cent
Lead	none	96.43	93.17
Barium	none	.....	6.05
Calcium	86.42	3.20	none
Tin	.....	.....	trace
Antimony	.....	.....	0.0017
Copper	0.16	.....	0.0032
Zinc	none	.....	trace
Aluminum }	3.55	.....	none
Iron }	....	.....	0.0006
Bismuth	....	.....	0.055
Mercury	....	.....	none
Magnesium	0.29	.....	0.0008
Sodium	0.55	.....	.....
Carbon (by diff.)	9.03	.....	.....

Photomicrographs are in accord with the thermal equilibrium diagram and show a eutectic of lead with a lead-barium compound (presumably Pb_3Ba). From the diagram published in the article referred to,[a] it appears that an examination was made of an alloy containing as little as 0.14 per cent barium, and that presence of eutectic was found therein. Judging from this, no solid solutions are formed unless with smaller amounts of barium. In the work carried out at this laboratory microscopic examination indicates the presence of eutectic in the alloys containing barium down to at least 0.50 per cent (Figs. 7 and 8). In the thermal study the alloy lowest in barium of which cooling curve was made—namely, 0.70 per cent barium—plainly shows the presence of eutectic. Its structure is not the completely homogeneous solid solution, rather being composed of homogeneous crystallites (either pure lead or solid solution with a very small amount of barium) surrounded at their boundaries by another component, a eutectic. In the alloys containing above 4½ per cent barium and up to 6 per cent barium, coarse rod-like crystals make their appearance in the micrographs, which presumably consist of the compound Pb_3Ba (Fig. 9).

In the ternary calcium-barium-lead alloy, containing slight amounts of other elements (Frary metal), the eutectic forms at a slightly lower temperature than is the case with the binary barium-lead eutectic. That is, from study of the photomicrographs and thermal equilibrium of Frary metal the eutectic is found to be at a temperature of 284 deg. C. instead of 291 deg. C.; otherwise, however, the structure is such as would be expected from a combination of the binary alloys calcium-lead and barium-lead. There are, however, some indications of solid solutions being formed in the alloy up to about 0.2 per cent calcium and 0.4 per cent barium. The structure consists of homogeneous grains of lead, probably containing some calcium and barium in solid solution, surrounded by eutectic of this solid solution with lead-barium compound (Pb_3Ba), together with crystals of lead-calcium compound (Pb_2Ca) embedded in this ground mass of solid solution and eutectic (Fig. 10). The critical points found in thermal study of some of these alloys are given in Table II.

As indicated by Table II, there is a range of tempera-

[a] After our work was completed an abstract appeared in *Chemical Abstracts*, vol. 15, p. 662, describing an investigation of barium-lead alloys first published in *Zeitschrift für Metallkunde*, Oct. 1, 1920 ("The Constitution Diagram of the Alloys of Lead and Barium," by J. Czochralski and E. Rassow). Our work was in fact practically completed before that date, and is corroborated by the results reported in the article.



FIGS. 7, 8, 9. MICROSTRUCTURE OF Ba: Pb ALLOYS
Etched with 2 per cent $AgNO_3$ in alcohol. × 50.

Fig. 7—Ba 0.50 per cent. Small amount of eutectic in cast specimen. Fig. 8—Ba 1.39 per cent. Dendrites of lead in cast specimen. Fig. 9—Ba 5.5 per cent. Plates of Pb_3Ba in eutectic ground mass. (Slowly cooled specimen.)

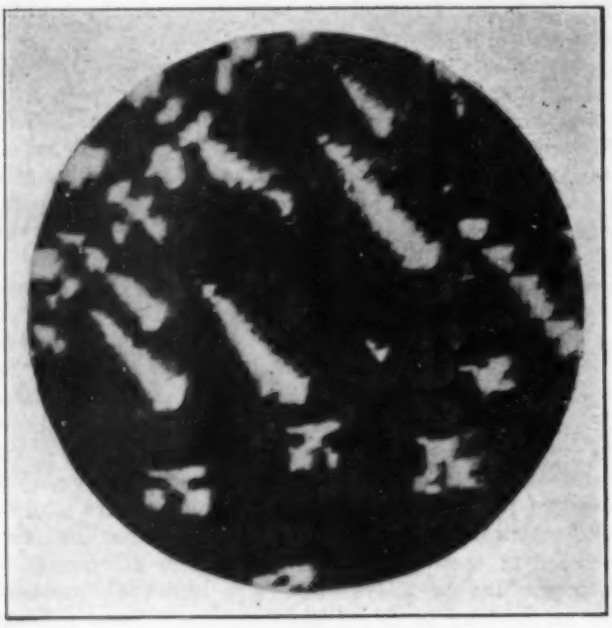


FIG. 10. TOP OF SLOWLY COOLED SPECIMEN OF FRARY METAL. × 250

Etched with HNO_3 and picric acid. White crystals of Pb_3Ca and gray areas of lead (or lead containing a little calcium and barium in solid solution), surrounded by dark areas of eutectic.

ture in cooling such an alloy from a molten state, through which freezing of some of its components continues until complete solidification is reached. The binary barium-lead alloys, in the range studied, melt at a lower temperature and have greater apparent fluidity than pure lead. In the binary calcium-lead alloys, the complete solidification point is at the melting point of lead, but the presence of lead-calcium compound gives a somewhat higher complete liquefaction point. In the ternary alloy the latter point is above the melting point of lead, while the solidification point is lower than that of lead. This range of temperature through which solidification takes place in Frary metal is no greater, however, than the range of temperature through which most tin base bearing metals are partly fluid and partly solid.

The practical pouring temperature of any metal should, of course, be well above its complete liquefaction point, the best temperature logically depending upon the size, shape and temperature of the mold into which it is

TABLE II. THERMAL ANALYSIS OF ALLOYS

Alloy				Complete Liquefaction Point Deg. C.	Point at Which Most of the Metal Freezes Deg. C.	Complete Solidification Point Deg. C.
Barium Per Cent	Calcium Per Cent	Mercury Per Cent	Lead			
1.20	....	....	Remainder	317	317	291
....	0.80	....	"	440	327	327
1.20	0.80	....	"	446	316	284
1.20	0.80	0.25	"	445	314	280

TABLE III. AGING EFFECT EXHIBITED BY Ca:Ba:Pb ALLOYS.

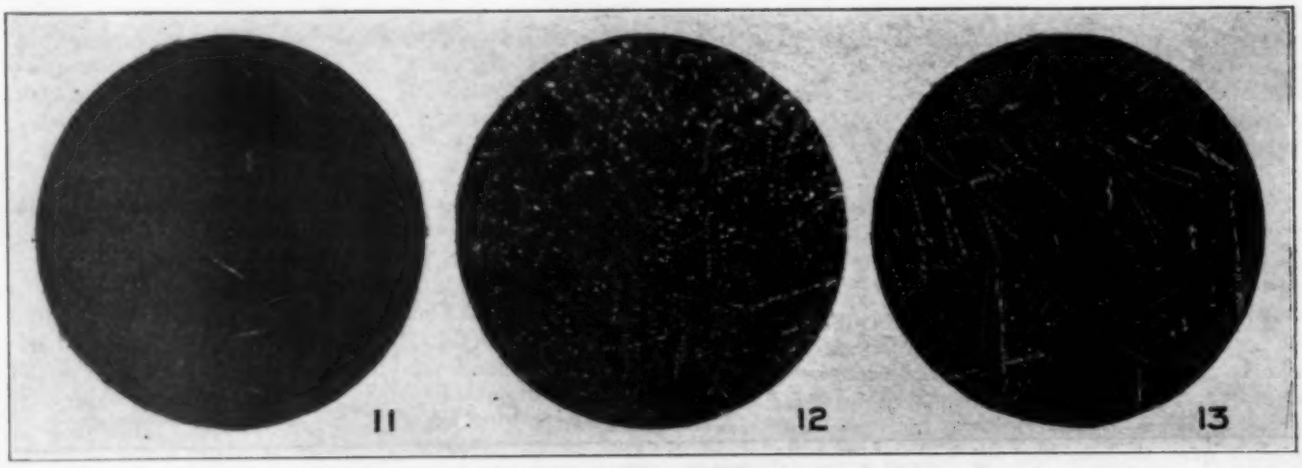
No.	Alloy Composition in Per Cent				Brinell Hardness Numbers Age of Specimen		
	Barium	Calcium	Mercury	Lead	1 Hr.	7 Days	28 Days
155	2.00	0.77		Remainder	25.7	29.2	31.5
157	1.20	0.77		"	17.6	26.1	28.4
159	0.40	0.77		"	13.8	21.8	24.5
219	1.00	0.50		"	18.7	22.2	23.5
218	1.00	0.50	0.2	"	22.6	24.4	24.7

TABLE IV. HARDENING Ca:Ba:Pb ALLOYS BY HEAT-TREATMENT

Specimen	Brinell Hardness Numbers Before Heat-Treatment	After Heat-Treatment
½ in. extruded rod	15.0	29.6
½ in. O. D., ⅛ in. I. D. extruded pipe	11.2	25.0
Sheet	14.4	25.3
Swaged metal	12.3	23.5

to be cast. Other lead base alloys of the class of bearing metals and type metals melt at a comparatively low temperature, corresponding closely to the melting point of antimony-lead eutectic, and there is in most of these alloys only a short range of temperature between their complete solidification and liquefaction points; whereas Frary metal begins to melt at a temperature closer to the melting point of lead itself and corresponds in its comparatively wide melting range of temperature more nearly to tin base babbitt metals. In remelting and pouring into castings, therefore, it is necessary to use a higher temperature than with lead base alloys containing antimony.

Combination with oxygen in general takes place the more readily the higher the temperature. Frary metal does not oxidize or form dross to any greater extent than lead itself or other similar alloys at the temperature in question. In remelting ingots or other cast shapes of any metal or alloy, to avoid oxidation or drossing, the crucible, pot or ladle should, when practicable, be first heated to a temperature above the melting point of the metal, a small part of it first melted, and then the remainder added a little at a time at the rate at which it melts. With some alloys there may be



FIGS. 11, 12 AND 13. HARD CRYSTALS IN RELIEF ON POLISHED BEARING METALS. × 50

Fig. 11—Ba 4.65 per cent; Pb remainder; slowly cooled; a few plates of Pb_3Ba.

Fig. 12—Cast Frary metal; Pb_3Ca crystals in relief.

Fig. 13—Cast babbitt (Sn 88.9; Sb 7.4; Cu 3.7); etched with 2 per cent HNO_3 in alcohol. CuSn in relief.

a tendency under certain conditions for one element to oxidize more readily than another. However, Frary metal, as now produced, shows no tendency toward loss of its constituent elements by oxidation, when remelted by ordinary good practice. Alloys containing only barium and lead, on remelting, lose barium by oxidation. The calcium-lead alloys as made in this laboratory with the purchased metallic calcium, analysis of which is shown in Table II, do not act in this way, although calcium itself oxidizes very readily in the atmosphere. The surface of the molten metal has a very bright silvery appearance, free from oxide. The cause for this may be in the presence, as an impurity in the metallic calcium used, of a very slight amount of some other element. The absence of any tendency in Frary metal to lose its constituent elements by oxidation is probably due to a similar protective or deoxidizing action. The addition of small amounts of some metallic elements has proved beneficial, whereas the presence of slight amounts of other elements is harmful and must be avoided.

Peculiar Properties

Cast specimens of some of the alloys have shown a remarkable increase in hardness and strength upon aging. The cause of this change which takes place in the solid metal may be similar to the theory advanced for a somewhat like hardening which takes place in duralumin.[10] This is more pronounced with the alloys containing the lower percentages of calcium and barium. The period over which the change in hardness takes place is shortened by the addition of some other elements.

The hardness of the alloy, when in certain forms, can be increased by heat-treatment. In this respect also its behavior is similar to that of duralumin.

Pure lead, as is well known, emits a very dull sound when struck, while these alloys are quite remarkably resonant. This appears to be largely due to the presence of barium, since we have shown that cast lead containing only 0.08 per cent barium is quite highly sonorous, emitting a clear bell-like sound on being struck.

Requisites of Bearing Metal

Frary metal, as described above, has a very large field of usefulness, especially as an excellent bearing metal. It has been found valuable for many purposes where strength and hardness is required, and can be readily cast in brass or iron molds, or made into die castings. It has also found use in the form of extruded pipe, tubing and rod; rolled sheets; and in swaged forms. As a bearing metal it has strength without brittleness, and also remarkable anti-frictional properties, while retaining largely the characteristics of lead in respect to plasticity (malleability, unctuousness).

It is generally recognized that the structure which renders an alloy suitable for use as a bearing metal consists of a crystalline component embedded in a plastic ground mass. The purpose of this desired structure is to give sufficient hardness to the bearing metal to enable it to resist the required pressure and at the same time impart to it the quality of plasticity, so that the bearing will adapt itself to any irregularities in fit and alignment. The metal should have the greatest hardness compatible with the necessary plasticity; this hardness, however, being much less than the hardness of the shaft so that in case of injury the latter will not be scored, but the bearing metal itself will suffer. A metal having these properties of hardness combined with plasticity will have good anti-frictional qualities, since, as generally thought of, this term probably involves a low coefficient of friction and also so-called unctuousness. The former is actually the lower with the greater hardness, and the latter, used in this connection, may be simply the property of plasticity.

It appears from photomicrographs and from the working qualities of Frary metal that its structural components have all of these characteristics in a marked degree. Figs. 12 and 13 show photomicrographs of Frary metal, and a tin base babbitt metal prepared under the same conditions. These indicate that the structure of Frary metal is very similar to that of high-grade tin base bearing metals, and the similarity is even more notable when compared with the somewhat different structure of other lead base bearing metals. In Frary metal the presence of lead (or solid solution of lead with small amounts of calcium and barium) in the ground mass is undoubtedly partly the cause of the high degree of plasticity which is characteristic of the metal, and it is evidently distributed throughout the alloy in such a way as to result in no sacrifice of hardness.

TABLE V. HARDNESS OF VARIOUS BEARING METALS AT MODERATE TEMPERATURES

Alloys	Per Cent Lead	Per Cent Tin	Per Cent Anti-mony	Per Cent Copper	Brinell Hardness Numbers 20 Deg. C.	50 Deg. C.	100 Deg. C.	150 Deg. C.
1	..	91	4.5	4.5	24	....	12	....
2	..	88.9	7.4	3.7	28	....	14.5	....
3	..	85	7.5	7.5	31	....	16	....
4	10	75	12	3.	29.5	....	13	....
5	48	40	10	2.	21.	....	9	....
6	77	10	12.5	0.5	25	....	13	....
7	80	5	15	...	22.5	....	10.5	....
Genuine babbitt	..	88.9	7.4	3.7	28.3*	23.5	13.8	9.0
Frary metal	97.5				29.6*	27.2	20.9	14.0

*At 25 deg. C.

In actual service bearings attain a temperature above normal, in many cases due to faulty lubrication or other causes. Their value in service then depends upon their properties at such temperature. Metals in general decrease in hardness and strength with rise in temperature to zero at the melting points. The decrease appears in general to be approximately a linear function with change of temperature; therefore, at elevated temperatures, metals having low initial solidification points are at a disadvantage in this respect, as shown by the figures in Table V.

[10] "The Heat-Treatment of Duralumin," by P. D. Merica, R. C. Waltenberg and H. Scott. A. I. M. E., June 1919. See also "Slip Interference Theory of the Hardening of Metals," by Zay Jeffries and R. S. Archer, CHEM. & MET. ENG., vol. 24, p. 1057 (June 15, 1921).

Discovery of New Nitrate Lands in Chile

The Chilean Government has sent a mining engineer to Iquique to investigate a report of the discovery of a new nitrate zone, reports Consul Brett in *Commerce Reports*. A prospector claims he has found nitrate beds underlying a district of about 2,000 sq.km., where no nitrate was previously known to exist. The region is in the Province of Tarapaca, and it is said that the results of forty blasts, put in at distances of from 3 to 4 km. apart, show that beds of caliche from 2 to 3 ft. thick containing from 20 to 40 per cent of nitrate of soda underlie the region at a depth of 11 ft. below the surface.

Solvents for Cellulose Esters*

Review of the Principal Solvents for Nitrocellulose and Cellullose Acetate—Development of a Pure Anhydrous Ethyl Acetate Which Is Known Commercially as Acetic Ether and Which Appears to Possess Unusual Solvent Properties

By H. F. Willkie
Research Laboratory, U. S. Industrial Alcohol Co.

There are two general types of solvents for cellulose esters. The first type are the solid solvents, which act upon the nitrocellulose whereby it loses all structural form and together with the solvent passes into a homogeneous plastic mass. The combination of such a solvent with the cellulose ester is brought about through the application of heat or pressure, by the addition of a liquid solvent, or by a combination of these methods. The homogeneous plastic mass once formed may be worked under influence of heat and pressure into any desired shape. Examples of this class of solvents, which are also known as latent solvents, are camphor, acetanilide and triphenyl phosphate.

The second general class of solvents are the direct or liquid solvents, which dissolve directly without such aid as heat or pressure. These solvents first act upon the cellulose esters to form a colloidal mass, which, upon the addition of further solvent, becomes a free flowing solution which may be indefinitely diluted with the same solvent. These solvents produce solutions which evaporate to leave clear films of the cellulose esters. The solutions are used as lacquers and protective coatings for wood, metal and other products; as a covering for cloth in the manufacture of artificial leather, and in the production of photographic films. When once dry these films can be redissolved by a direct solvent, but cannot be molded under the influence of heat or pressure unless a latent solvent such as camphor be present. Consequently for many purposes combinations of direct and latent solvents are used. Some of the more generally known direct solvents are amyl acetate, acetone and ethyl and methyl acetates.

Because of the relative high cost of high-grade solvents such as amyl acetate it is desirable to dilute them with non-solvents or with other cheaper solvents which alone would not give satisfactory results. These diluents may add some useful property to the mixture or may merely act as thinners. Examples of non-solvents which often impart valuable properties to solutions are the alcohols (ethyl, methyl, propyl), fusel oil, benzine and benzene. Included with the direct solvents are the mixtures of solvents with thinners and other solvent mixtures made of combinations of two liquids which separately are non-solvents but together from a solvent, such as alcohol and ether.

Effects of Water in Solvent Mixtures

To the list of non-solvents should be added water. This non-solvent has given rise to a great deal of trouble in the development of the cellulose-ester industry, especially from the solvent standpoint. It is a precipitant of cellulose ester, and a solution of a cellulose ester in a hydroscopic solvent will take up moisture to the point of precipitation. A solution of a cellulose ester in a mixture containing a solvent and non-solvent will not evaporate to form a clear film, but will precipitate whenever during the course of evaporation of the solvent the unevaporated portion is no longer a mixture in which the cellulose ester is soluble. This rule, of course, applies to water. Consequently, the use of a hydroscopic solvent with a boiling point below 100 deg. C. will often result in precipitation, or film blushing, as it is known, unless great precaution is exerted to prevent absorption of water.

A solution in any solvent which evaporates rapidly enough to cause an appreciable lowering of the temperature of the surrounding atmosphere and thereby resulting in a precipitation of moisture upon the evaporating solution is apt to suffer from this same trouble, especially if the solvent is also hydroscopic. Because of this difficulty a high boiling point, at least above 100 deg. C., has been considered one of the prime requisites of a good solvent. The quality of a lacquer, imitation leather or photographic film depends first of all upon the use of a solvent or solvent mixture which will evaporate in such a manner as to eliminate water and thereby leave a clear strong homogeneous film free from precipitation or blush.

Some Properties of Amyl Acetate

Since 1882 amyl acetate has been the most important solvent for cellulose nitrate and has enjoyed extreme popularity due to its many important properties, among which are its high boiling point, low solubility in water, absence of hydroscopicity, its ability to stand high dilution with non-solvents (especially with benzene in the preparation of lacquers) and its property of producing smooth films of luster and high tensile strength. On the other hand, amyl acetate has low solvent power in comparison with acetone and ethyl acetate. Its variability of composition and, above all, its rapidly increasing scarcity, which has been accompanied by a corresponding rise in price, are factors which have tended to limit its use as a solvent for cellulose esters.

In the past few years there has been a tremendous growth of the industries based upon cellulose-ester solutions. The almost universal use of automobiles has increased the demand for artificial leather, the airplane has brought in an increased demand for dopes or lacquers, and the motion picture industry consumes tremendous quantities of films. Together with increased use of these products has come the rapidly decreasing supply of the industry's most dependable solvent and the necessity of, and demand for, new solvents or solvent mixtures. Out of this need first came greater dilution of the amyl-acetate solvents with non-solvents —the introduction of varying quantities of methyl ace-

*A paper read before the Section of Cellulose Chemistry at New York City on Sept. 7, 1921, and published by permission of the American Chemical Society.

tate, which could be obtained in an anhydrous condition but which soon became prohibitive in price—and later the rather general introduction of ethyl-acetate mixtures consisting of ethyl acetate and alcohol and ethyl acetate and benzene, with varying amounts of water dependent upon the source and method of manufacture of the ethyl acetate. These solvent mixtures are used together with a quantity of high boiling solvent, such as amyl acetate, sufficient to produce a solution which will evaporate without fogging. However, these solvent mixtures do not and cannot take the place of amyl acetate, and the demand for such a solvent is not satisfied by them.

Production of Anhydrous Ethyl Acetate

This unsatisfied demand has led to experimentation with ethyl acetate, which has long been known to be a powerful solvent for nitrocellulose, but with which great difficulties had been encountered in attempting to produce it as an anhydrous product. However, this work has resulted in the development of successful and economical processes for the production of anhydrous ethyl acetate free from both alcohol and water and of many other anhydrous esters and solvents.

Heretofore but little has been known regarding ethyl acetate which is free from water and alcohol. However, acetic ether,[1] as this product is designated in this paper, promises to take the place to a great extent of amyl acetate and to extend greatly the field of cellulose ester solutions. Since acetic ether is produced from acetic acid and alcohol, the possible supply is practically unlimited. Furthermore, it should not increase materially in price, but naturally it should decrease as its manufacture on a large scale becomes justified through its increased use.

Acetic ether has suffered and still suffers from adverse criticism, due to information based on experiments with impure products and lack of knowledge of the behavior of the pure anhydrous preparation. References have been made repeatedly in the literature to the tendency of acetic ether to take on a strong acid reaction on standing.[2] Pure acetic ether as such or pure acetic ether diluted with 95 per cent alcohol does not show any indication of this objectionable property. Samples of acetic ether, and acetic ether and alcohol, after standing for 1 to 2 years have shown only a slight trace of acidity or even complete freedom from the same. After eighteen months' time four representative samples showed: 0.009 per cent, 0.024 per cent, 0.017 per cent and 0.009 per cent of free acetic acid. Acetic ether is stable even when treated with hot water.

Iron drums in which acetic ether had been stored for months have shown no evidence of corrosion, nor was the ester itself discolored. Chemical tests of acetic ether show that the supposed acid-developing tendency cannot be too strongly denied.

Another objection raised to acetic ether and which is found frequently in the literature is its alleged hydroscopicity.[3] It is known, however, that acetic ether is not hydroscopic, but on the other hand takes up moisture very slowly. High-grade acetic ether such as produced by the process previously referred to, after standing in a storage tank with a loose cover for a month, showed no action on metallic sodium when the latter was placed in it. Acetic ether stored in drums for 6 months gave the same result.

A third commonly repeated objection to acetic ether is its volatility or low boiling point (77 deg. C.).

Having discussed briefly the more common objections to acetic ether, some of its properties will now be considered. It is a colorless, limpid, pleasant smelling fluid, entirely free from disagreeable and poisonous fumes. It evaporates without a visible or detectable residue. Being a pure compound, it evaporates at a uniform rate. Acetic ether is unaffected by light or air. Samples stored for months in bottles or exposed to the air in storage tanks have shown no signs of deterioration. It is a powerful solvent for nitrocellulose and is a good solvent for the more soluble forms of cellulose acetate.

Tests With Nitrocellulose

In this connection the description of a series of experiments which were carried on to determine the nature of acetic ether and acetic ether-ethyl alcohol mixtures as solvents for nitrocellulose might be of interest. Samples of nitrocellulose were obtained from the Hercules Powder Co. and showed the analyses given in Table I.

TABLE I. PROXIMATE ANALYSES OF NITROCELLULOSE SAMPLES

(In per cent)

Description	Nitrogen	Insoluble in Ether and Alcohol	Insoluble in Acetone	Ash	Moisture
"L," low viscosity.....	12.00	0.40	0.15	0.14	27.9
"P".....	11.14	3.25	0.26	0.12	38.1
"M," medium viscosity..	12.13	0.08	0.15	0.13	29.2
"H," high viscosity.....	12.06	0.10	0.08	0.14	28.0
"V.H.," very high viscosity.....	12.18	2.15	0.30	0.20	32.3

These samples were wet with alcohol when received and were all dried at about 50 deg. C. before using. They are designated by the letters "L" "P" "M" "H" and "V.H." respectively.

The alcohol used was 95 per cent ethyl alcohol containing ½ per cent of benzene. The acetic ether and alcohol were mixed so as to give mixtures containing 10 per cent of acetic ether and 90 per cent of alcohol, 20 per cent of acetic ether and 80 per cent alcohol and so on, advancing by tens to the pure acetic ether. These mixtures are designated as "10 per cent," "20 per cent," "30 per cent," . . . "100 per cent" acetic ether.

To weighed samples of the nitrocellulose in large test-tubes were added measured amounts of the different ester mixtures; a separate tube was set up for each solvent with each sample of nitrocellulose. In each case slightly less of the ester mixture was added than had been found necessary for complete gelatinization of the nitrocellulose.

The tubes were well stoppered and were allowed to stand for 24 hours, when more ester was added in each case. This was repeated until just enough solvent had been used in each case to dissolve the nitrocellulose, while the addition of more solvent merely rendered the mixture fluid.

The solubilities expressed as ounces of nitrocellulose per gallon of solvent were found to be as shown in Table II and the curves prepared from these data are shown in Fig. 1.

From these experiments it will be seen that acetic ether has a high solvent power for the various samples of nitrocellulose, dissolving from 11.2 to 30 oz. per gallon of solvent. Further, it may be noted that the high dilutions possible with 95 per cent alcohol is accom-

[1] It is appreciated that this does not conform with exact chemical nomenclature, but the term is used here because of its commercial significance. In the trade "ethyl acetate" refers to the 85 per cent material, and "acetic ether" is used to designate the 99 to 100 per cent ethyl acetate.

[2] "Nitro-Cellulose Industry," by E. C. Worden, vol. 1, pp. 230 and 434.

[3] "Nitro-Cellulose Industry," by E. C. Worden, vol. 1, p. 434.

TABLE II. SOLUBILITIES OF NITROCELLULOSE SAMPLES IN VARIOUS MIXTURES OF ACETIC ETHER AND ALCOHOL.

(Ounces of cellulose per gallon of solvent)

Solvent	Nitrocellulose Samples L	P	M	H	V.H.
10 per cent acetic ether	....	25.4	....	....	....
20 per cent acetic ether	30.6	27.8	26.5	23.6	11.7
30 per cent acetic ether	36.7	28.7	29.0	24.5	12.2
40 per cent acetic ether	37.2	29.4	29.7	25.7	13.0
50 per cent acetic ether	38.0	30.0	30.0	25.7	13.5
60 per cent acetic ether	37.7	29.4	28.7	25.7	13.2
70 per cent acetic ether	37.2	28.9	28.4	25.3	13.0
80 per cent acetic ether	35.8	28.5	28.1	24.6	12.8
90 per cent acetic ether	33.5	26.8	27.3	24.0	12.2
100 per cent acetic ether	29.7	23.4	23.5	23.0	11.2

panied by an increase rather than decrease in the solvent power of the mixture.

A similar set of experiments showed the possibility of diluting the acetic ether with benzene to the point of a mixture of 70 per cent of benzene and 30 per cent of acetic ether. Although solvent for the various nitrocelluloses, the dilution with benzene beyond a 50-50 mixture reduced the solvent power appreciably.

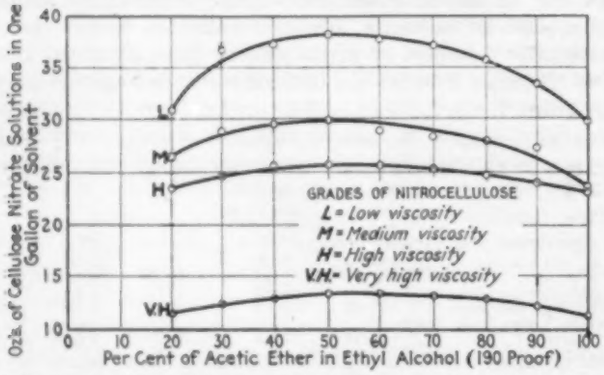


FIG. 1. SOLUBILITY OF NITROCELLULOSE IN ACETIC ETHER-ETHYL ALCOHOL MIXTURES

Curves showing the relative viscosities of 5- and 10-oz. solutions of nitrocellulose in these solvent mixtures are shown in Figs. 2 and 3.

The solvent properties of acetic ether for cellulose acetate were shown by experiments with three different lots of cellulose acetate obtained from the Eastman Kodak Co. over a period of 3 years. All dissolved in anhydrous acetic ether to the extent of about 25 oz. to 1 gal. of solvent and gave good workable solutions of 10-oz. strength from which films were produced. Another sample of cellulose acetate was found to be soluble to the extent of 20 oz. per gallon. Later a sample of salvage cellulose acetate proved to be insoluble in acetic ether, but experiments demonstrated that this sample was also insoluble in other cellulose acetate solvents.

Besides being a powerful solvent for the cellulose esters, acetic ether, alone and together with small percentages of alcohol or water, or diluted by with as much as 50 per cent of chemically pure benzene, will produce solutions leaving satisfactory films upon evaporation.

Clear, strong films were produced by permitting the following solutions to evaporate under the ordinary atmospheric conditions of the laboratory: Solutions of various samples of nitrocellulose in acetic ether, acetic ether diluted with 5 per cent of 95 per cent alcohol, acetic ether wet with 2 per cent water, and acetic ether diluted with an equal volume of c.p. benzene; a solution of cellulose acetate in acetic ether, and one of half cellulose acetate and half cellulose nitrate in acetic ether.

Acetic ether is an example of a low boiling solvent

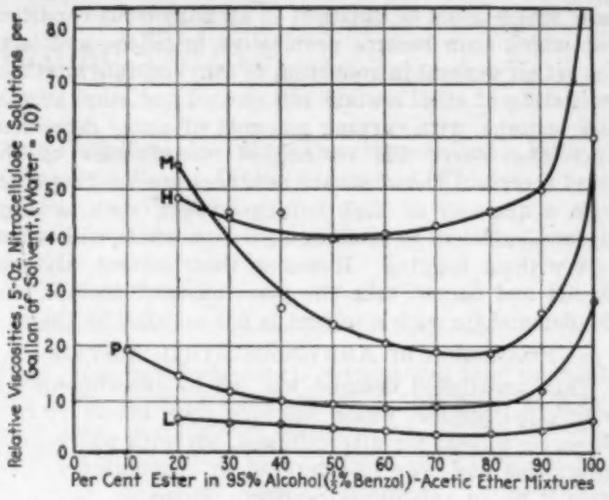


FIG. 2. RELATIVE VISCOSITIES OF 5-OZ. NITROCELLULOSE SOLUTIONS

(b.p. 77 deg. C.) giving a result which in the past has been considered possible only from a non-hydroscopic solvent boiling above 100 deg. C., such as amyl acetate. The effect of water upon the low boiling solvents and upon hydroscopic solvents has already been discussed.

The explanation of this unusual and important behavior of acetic ether depends chiefly upon its characteristic property of forming constant boiling mixtures with water. Among the constant boiling mixtures of acetic ether with other liquids are the following:[1]

With Water. Acetic ether 91.4 per cent, water 8.6 per cent. Boiling point, 70.45 deg. C.

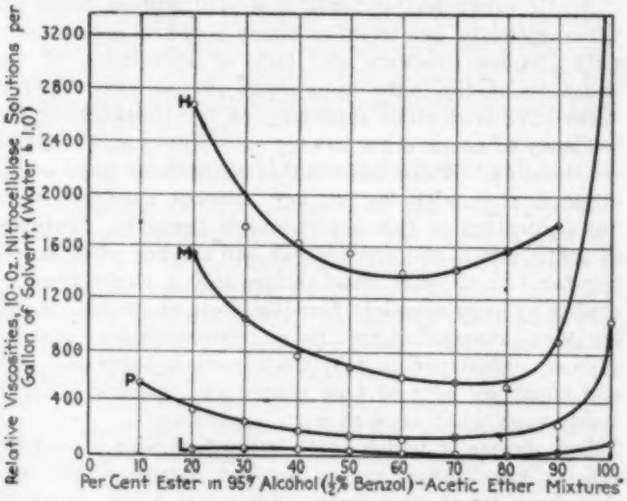


FIG. 3. RELATIVE VISCOSITIES OF 10-OZ. NITROCELLULOSE SOLUTIONS

With Alcohol. Acetic ether 69.4 per cent, alcohol 30.6 per cent. Boiling point, 71.8 deg. C.

With Alcohol and Water. Acetic ether 83.2 per cent, alcohol 9.0 per cent, water 7.8 per cent. Boiling point, 70.3 deg. C.

The relative low boiling point of acetic ether becomes a decided advantage. It makes possible rapid work. Further, by control of the temperature of evaporation and other atmospheric conditions such as concentration of evaporating solvent any desired rate of evaporation may be maintained.

Baltimore, Md.

[1] Ryland, *Am. Chem. J.*, vol. 22 (1899).

German Chemical Industries

FROM OUR SPECIAL CORRESPONDENT

ESSEN, Nov. 28, 1921.

JUDGING from the commercial reports of the principal German newspapers, opinion as to the prospects and future of the German chemical industries is still divided. Pessimists still reckon on the possibility of France demanding that the greater part of the chemical works be dismantled, on the ground that in case of a new war they could be able to manufacture war gases. On the other hand, the stock exchange, which at all times is a better barometer for the course of future events, does not seem to share such a gloomy view.

While in normal times, and even until recently, the market for industrial debentures varied generally only between 95 and 100 per cent, the recent rush to invest money caused the price for these debentures to reach a figure never known before, this increase varying in proportion with the confidence the public has in the future prospects of each individual undertaking. The 4½ per cent debentures of the undertakings united in the great dye trust have beaten all previous records. The obligations of the Badische Anilin und Soda-Fabrik and the Elberfelder Farbenfabriken vorm. Friedr. Bayer (yielding 4½ per cent interest in paper marks) reached their highest bid at 180 per cent, a price which has never previously been known to be paid in Germany for industrial debentures of any kind.

CHEMICAL MARKETS

The situation in all branches can be considered favorable, although the intensity of buying has somewhat relaxed this month, but everything offered is readily sold. Prices are increasing continually and in consequence contracts cannot be placed at fixed prices. As the prices have, however, reached an exceptional and one is very much inclined to say a phantastic level, buyers are somewhat more careful, with the result that the situation has begun to ease a little. In consequence the available quantities of chemicals offered in the open market were much smaller than usual and were readily disposed of. As examples may be mentioned borax, which had reached the exorbitant figure of 45 marks per kilogram and has since dropped to 37, with the result that it has disappeared from the market entirely; mercury is much in demand, but only very small quantities are to be had, these changing hands at 300 marks per kilogram exclusive of bottles; sulphur in lumps reached 6.50 to 6.75 marks per kilogram; sulphuric acid as supplied through the German ammonia syndicate to the byproduct coking plants has also been increased in price —to 83 marks per 100 kg. from Nov. 1.

TAR PRODUCTS

The market in anthracene is very quiet due to the fact that the large dye works accumulated thousands of tons during the war when it was very cheap and are thus fully supplied with this material for a number of years to come. The comparatively cheap price paid for anthracene during the war is explained by the fact that the manufacture of oils for fuel and lubricating purposes was of primary importance and anthracene was then considered merely a byproduct.

Benzene, toluene and xylene have been increased in price during October, but in spite of these increases these products are still sold at a figure much below the rates prevailing on the world markets. The rapidly jumping prices for imported gasoline have again increased, with the result that the demand for benzene exceeds the available quantities by far.

To relieve the acute shortage of liquid fuel the benzene syndicate, which is under government control, has recently introduced a new standard motor fuel called "tetralitbenzol." It consists of two parts by weight of motor benzene, one part motor tetraline and one part of 95 per cent alcohol. This fuel is introduced and distributed now on a considerable scale and has proved very serviceable for motor cars or any other internal combustion motors. A great number of mixing plants have been erected all over Germany so as to insure an even distribution all over the country. The new fuel has been well received by the consumers and by its use the amount of benzene available for home consumption is increased by 4,000 tons per month through this addition of tetraline and alcohol, so that Germany is practically independent of foreign supplies of motor fuel.

DYES

The turnover in dyes is somewhat quieter and in the export trade the Swiss competition is keenly felt. The American and English competition is also a disturbing factor. Trade with Italy is much impaired by the peace treaty with that country which makes compulsory the supply by Germany of certain quantities of dyes and chemicals.

On the whole the chemical industry is suffering acutely from the general scarcity and inferior quality of fuel. Apart from this impediment in production, the works are sold out for several months to come, so that today only goods for supply in January or February can be promised. Owing to the shortage of railway cars, even wholesale dealers cannot supply promptly and for many chemicals no offer at all can be had.

Surface Defects on Brass Sheet

H. A. Hays read a paper on "The Rolling of 70:30 Brass" before the Birmingham (England) Metallurgical Society in November, 1921. As reported by the *Iron and Coal Trades Review*, he noted that the surface defects chiefly met with in brass strip and sheet could be divided into three main classes: (1) Spilly areas, (2) scratches, rolled-in mill scale or dirt, (3) stains. The first named was the most serious and was too frequently met with. Spilly areas were due to bad pouring, which caused splashing of partly solidified metal on the surface of the ingot mold, cracks and serious porosity of the ingot mold and fragments of sand, metal, etc., mixed in with the mold facing. The steelworks practice of machining blooms all over before rolling into strips could be advantageously adopted.

Mechanical defects were altogether too frequent. The rolling-in of mill scale and dirt could be avoided by adopting closed muffles for all heating operations and the keeping the floor of the rolling mill clean, and, as far as possible, keeping the material off the floor. Continental manufacturers are able to produce excellent finish by the use of steel rolls, the use of which in England is limited.

Recent work by the Non-Ferrous Research Association indicated that the removal of grease from the material before annealing greatly helped in preventing staining. Insufficient cleaning and pickling or the presence of chlorides in the wash water resulted in the material becoming badly stained after being left standing for some time.

Synopsis of Recent Chemical & Metallurgical Literature

British Steel-Works Practice.—R. H. Archer Coulson, president of the Cleveland (England) Institution of Engineers, delivered an address[1] before that body in which he outlined the changes in their industry which might possibly be used to offset high cost of labor and fuel. Given a well-designed plant, built with the idea of saving fuel, the main determining factor of success is *reliability* of the various independent operating units. Material handling should be simple and continuous; avoid intricate machines which will require heavy attendance and upkeep costs. Again, material may get into a department efficiently, but get out wastefully. The speaker feels that storage battery locomotives will be a great time and money saver. Low-ash coke, pure limestone and high-grade ore should be insisted upon; poor chemical and physical properties of coke are especially expensive at any price. Much yet remains to be known about the factors which promote combustibility—that prime requisite of coke as a blast-furnace fuel. Irregularities in practice should be avoided if at all possible—a furnace running well on fine ore will show distress if given several charges of lumpy ore. Pure fluxes are of great importance in the open-hearth furnace, not so much from the increased tonnage, but the loss of iron in the slag. Silica and magnesite brick are not so good as before the war. Gas houses should operate, not to make the richest gas, but the gas which burns with the highest temperature. Waste-heat boilers are to be recommended. After all, the most important factor is the weight of ingot required to produce a ton of finished material. Given sound ingots, good heating practice is of great importance, in keeping this weight down and in reducing power and repair bills. Continuous operation is essential to economy in every department, even though workmen are paid by tonnage rates. Reliable, simple, stout, and if possible automatic electrical equipment will cut down incidental and exasperating delays remarkably. Cleanliness and order will work to the same ends. Finally, but perhaps most important, every member of the staff and every workman should have a desire to do his best, to have "the pride of craft."

Water Japan Installations.—The November issue of the *General Electric Review* contains an article by Wheeler P. Davey and P. Dunning describing several installations at the General Electric Co.'s plants using the water japan developed in the research laboratories of the company. This water japan is an emulsion of an asphalt oil base in water. It may be applied by two methods: the electric dip, in which the articles to be coated are charged positively; the hot dip, in which the articles are preheated before dipping in the japan. (See CHEM. & MET. ENG., May 19, 1920.)

Two small installations at the Schenectady works are described briefly, followed by a discussion the installation at the Sprague works, which is the first to use water japan on a large scale. The latter consists of three electrically heated conveyor ovens of the vertical intermittent type. Two of these have a maximum capacity of 2 tons per charge; the third, 3 tons per charge. The dip tanks, placed in a pit below the floor level, are provided with cooling coils and air jets so arranged that the temperature of the japan is always below 70 deg. F., even without the use of a circulating pump. Each tank holds about 900 gal. of japan. This provides enough heat capacity in the japan itself to prevent undue temperature rise during dipping.

Articles to be japanned are hung from hooks on the bars of the conveyor, if large, or placed in baskets, if small. After preheating to about 500 deg. F., the articles pass through the dip tanks at a speed of not less than 6 in. per second, and then back to the oven, where the japan is baked for 20 to 30 minutes. When operating on a load of 4,000 lb., the efficiency of the 2-ton ovens for preheating plus baking is 11 lb. per kw.-hr. With smaller loads the efficiency is, of course, less. For instance, if the load is decreased to 1,800 lb., the efficiency is only 6 lb. per kw.-hr. The 3-ton oven has never been loaded to its maximum capacity, so that actual data are not available, but it is estimated that if it were so loaded its efficiency would be 14 lb. per kw.-hr. These figures compare favorably with those obtained with box-type or other intermittent ovens.

The relative freedom from drip, which is a characteristic of water japan, prevents material on one bar from being marred by japan dropping from the next higher bar and also prevents prohibitive scarring of the work which is dipped in baskets. Data taken on metal totaling several thousand square feet in area show a coverage of a little more than 200 sq.ft. per gal. of water japan. In spite of the large amount of metal that is japanned daily by the ovens at the Sprague works, it is not necessary to measure the concentration of the japan oftener than once a week. Since the solvent (water) is relatively non-volatile, there is no need for the daily addition of "thinner," so that the low initial cost of water japan is further supplemented by the saving in the cost of thinner. These advantages are nevertheless of but supplementary importance compared with the main purpose for which the water japan was developed—the absolute elimination of fire risk.

Contribution to the Study of Titanium.—The July-August, 1921, issue of *Annales de Chimie* contains the results of the research work on titanium made by Maurice Billy at the Institut de Chimie Appliquée (pp. 5 to 54). His study consisted in obtaining the raw materials for the preparation of pure metallic titanium, gaseous and solid hydrates, oxides (TiO, Ti_2O_3, Ti_2O_5, Ti_3O_5), crystallized persalts, complex double sulphates and the determination of the degree of oxidation of the compounds obtained in acid solution in the presence of hydrogen peroxide.

He obtained the raw material used in his study by mixing 1 part of commercial titanium anhydride with 6 parts of sugar and transforming this into chloride by calcining, pulverizing, heating to 1,000-1,200 deg. C. in a current of dry chlorine in a porcelain tube. The impurities of the resulting chloride were separated by an agitation with sodium amalgam and a fractional distillation at 135-137 deg. C. under normal pressure.

After passing in review the different methods employed in the preparation of metallic titanium he describes in detail the method he employed, based on the reaction

$$TiCl_4 + 4NaH = Ti + 4NaCl + 2H_2$$

and gives the schematic arrangement of the apparatus used (p.14). Qualitative and quantitative tests have shown no trace of impurities.

Nascent titanium absorbs hydrogen, giving a black mass, which is titanium hydride. He describes the method of preparation and the apparatus used (p. 21).

The only titanium oxide which can be obtained easily in a perfectly pure state is TiO_2 and this served for the preparation of the other oxides by reduction with hydrogen or by the action of metals having a greater affinity for oxygen. After describing in detail the preparation of pure TiO_2 he passes in review the methods formerly used for the reduction by hydrogen and then gives his method with the schematic arrangement of the apparatus used (p. 27). Similarly he passes in review the methods formerly used for the reduction of TiO_2, especially by magnesium and zinc, and gives his procedure and came to the result that the most convenient metal is titanium and that the mixture TiO_2—Ti heated in a specially constructed furnace shown schematically on pp. 39 and 41 he was able to obtain all the oxides according to the degree of heating. Thus:

Between 700– 800 deg. C. he obtained a blue oxide, Ti_3O_5.
Between 900–1,000 deg. C. he obtained a violet oxide, Ti_2O_3.
Between 1,100–1,200 deg. C. he obtained a black oxide, Ti_3O_5.
Between 1,400–1,500 deg. C. he obtained a brown oxide, TiO

He then studied the preparation of persalts and states that he has succeeded in preparing crystallized sulphates of titanium peroxide. He concludes with the statement that all the salts of titanium are not salts of TiO_2, as given by previous authors, but salts of $Ti_2O_5.H_2O_5$.

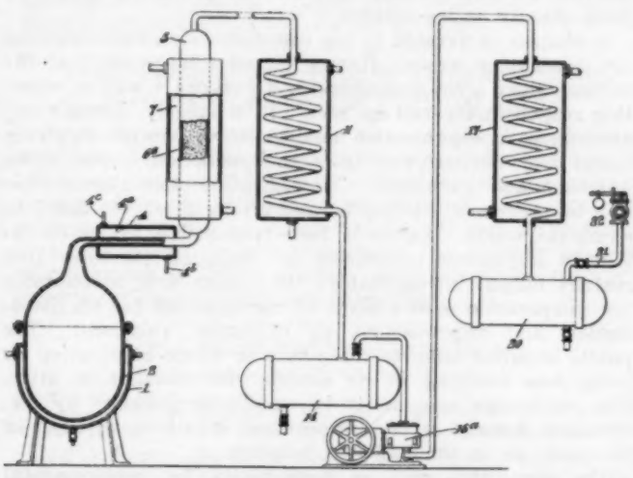
[1]Reported in *Iron and Coal Review*, Nov. 11, 1921.

Recent Chemical & Metallurgical Patents

American Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

Production of Acetaldehyde.—A process for the catalytic production of aldehydes, with particular reference to the manufacture of acetaldehyde from ethyl alcohol, is the subject of a patent granted to Arthur A. Backhaus of Baltimore and Fred B. Arentz of Curtis Bay, Md., assignors to the U. S. Industrial Alcohol Co. To carry out the process, the alcohol is introduced in the still 1 (see figure), which is heated by the steam jacket 2. The alcohol vapors are conveyed to the preheater 4, where they are heated to about 300 deg. C. by means of the oil jacket 4*a*. The vapors enter the catalyzer 5, which is filled with pumice stone, unglazed porcelain, charcoal or a similar granular porous



material upon which has been deposited the finely divided catalyzer metal. The catalyst used is copper, nickel, chromium or iron. The oil jacket 7 maintains the vapors in the catalyzer at approximately 300 deg. C. throughout the length of the tube, and a large percentage of the alcohol is decomposed to form acetaldehyde and hydrogen. The vapors passing out of the catalyzer are conducted through the condenser 11, maintained at a temperature of 20 to 30 deg. C., where any alcohol vapors present are condensed and are collected in the receiver 14. The acetaldehyde and the hydrogen pass out of the receiver and are conducted to the compressor 16*a*, where the gases are compressed to approximately 60 lb. per sq.in. The compressed gases then pass through the condenser 17, maintained at a temperature of 10 to 20 deg. C., where the acetaldehyde is condensed and collected in the receiver 20. In case the compressor 16*a* is not used, the temperature in the condenser 17 is kept at about 0 deg. C. by means of a brine bath. The hydrogen is conveyed away from the receiver 20 by the pipe 21, through the relief valve 22. The hydrogen may be collected in any suitable manner. (1,388,841; Aug. 30, 1921.)

Purifying Fuel Gases.—Charles J. Ramsburg of Pittsburgh, Pa., assignor to the Koppers Co., has obtained a patent for purifying fuel gases by a process in which the obnoxious constituents such as the sulphur compounds are removed from the gas through absorption in a water solution of sodium carbonate or a similar alkaline salt. It is common practice to pass the gases through boxes filled with iron oxide, but these boxes have to be cleaned frequently and replenished and consequently are expensive to maintain. This invention claims to reduce the quantity of iron oxide to a minimum inasmuch as the purification removes substantially all of the sulphur compounds from the gas before it passes into the iron-oxide boxes on its way to the mains. An efficient aëration process for regenerating the sodium carbonate solution after it has absorbed the hydrogen disulphide is also provided. This causes the purifying agent to give up its sulphur, thereby permitting a constant reflux of the sodium carbonate solution back to the process. The features of the process which relate to the principle of absorption by the alkaline solution and its regeneration are the invention of David L. Jacobson of Jersey City, N. J., and are covered by patent 1,390,037, which is also assigned to the Koppers Co. (1,389,980; Sept. 6, 1921.)

A New Detonator.—When finely pulverized cyanure chloride is introduced into an aqueous solution of sodium azide, there is obtained a new organic compound, cyanure triazide, which corresponds to the formula C_3N_{12}. Pure cyanure triazide consists of colorless crystals melting at 94 deg. C., is not volatile, but is saponified slowly by hot water, and explodes when subjected to concussion or when heated to 170 deg. C. It is particularly adapted for use as a priming agent as a substitute for mercury fulminate, lead azide or silver azide. In comparison with these priming agents, its inventor claims the following advantages:

(1) It is not poisonous in contradistinction to fulminating mercury and lead azide.

(2) It is not sensitive—that is to say not affected by moisture in contradistinction to fulminating mercury.

(3) It is resistant to and not changed by light in contradistinction to lead azide and to silver azide.

(4) There is no danger of reaction with a metal of the material of the detonator casing or capsule shell, as is the case with lead azide.

(5) It is fusible and its fusion point (94 deg. C.) is so low that the product, melted by a single heating on water or steam bath, can be poured without danger in the capsule shell. It solidifies therein after cooling and shows the density (specific weight) of 1.5.

(1,390,378; Erwin Ott of Basel, Switzerland, assignor to Dr. Edwin Hanton Faust of Basel, Switzerland, Sept. 13, 1921.)

Catalytic Oxidation With Silica Gel.—A patent has been granted to Dr. Ralph H. McKee of New York for the process of oxidizing certain gases in which hydrated silica gel is used as a catalyst. The method is shown to be particularly applicable to the oxidation of nitric oxide to nitrogen peroxide such as is required in the production of nitric acid. In one form of the process the gas stream flows through a series of chambers in which it is alternately exposed first to the action of silica gel and then to the action of water or dilute nitric acid. (1,391,332; Sept. 20, 1921.)

Book Reviews

ORGANIC COMPOUNDS OF MERCURY, by *Prof. Frank C. Whitmore* of the Northwestern University. 394 pp. New York: The Chemical Catalogue Co. Price, $4.50.

Probably very few organic chemists, whose chief interests lie in other fields, realize the rich variety and volume of work which has been done in the investigation of the organic compounds of mercury. This monograph by Prof. Whitmore has been "arranged to serve both the general chemist, who wishes to get a conception of what has been done in the field as a whole, and the specialist, who wishes to find out quickly what has been done in any particular portion of the field."

The reviewer is of the former class and from his point of view Prof. Whitmore has succeeded in achieving his purpose. The subject matter is well condensed, but nevertheless has a readable quality which is frequently lacking in mechanically compiled volumes. The omission of practically all detailed experimental material contributes to the readability of the volume. A very large number of literature references are given throughout the text and a bibliographical appendix includes a special list of patents on

organic mercury compounds. The subject index is unusually complete and has evidently been compiled with great care. A monograph which shows such evidence of careful preparation as the present volume naturally inspires the reader with a feeling of confidence. Prof. Whitmore's own experience in this field has enabled him to treat certain subjects very critically, and the present volume is happily not such as are more or less mechanically compiled by persons who have not been actively engaged in original research in the subjects of which they write.

The monograph is confined almost entirely to the true organic mercury compounds in which mercury is attached directly to carbon. No attempt has been made to include biological and pharmacological studies, on account of lack of space and "because of the unsatisfactory condition of the literature of this phase of the subject." The reviewer particularly welcomes the absence of erroneous theories and the results of faulty work of earlier investigators, which sort of material is often included by authors in a historical treatment of the subject. The book is remarkably free from typographical errors. Those whose interests lie in industrial fields might desire a fuller discussion of the rôle of mercury salts in the conversion of acetylene to acetaldehyde and also the mercury compounds of ethylene, since the latter also promise to be of industrial interest. Also the very fact that the biological and pharmacological literature is in such unsatisfactory condition, as noted by Dr. Whitmore, suggests that the same critical treatment of this phase of the subject by him would add greatly to the value of the book, at least for a certain class of readers. Nevertheless, the care which Prof. Whitmore has obviously given the preparation of this volume is a service which should be appreciated by all organic chemists. It has seldom been the privilege of the reviewer to read a monograph on any subject of chemistry which he could commend so unreservedly. BENJAMIN T. BROOKS.

* * *

WASTE IN INDUSTRY. By the *Committee on Elimination of Waste in Industry* of the Federated American Engineering Societies. Published by Federated American Engineering Societies, Washington, D. C., and sold by the McGraw-Hill Book Co., Inc., New York. 410 pages, illustrated. Price $4.

This is a report of the Committee on Elimination of Waste in Industry of the Federated American Engineering Societies, appointed by Herbert Hoover, the first president of that organization. It represents an intensive study of six typical branches of American industry undertaken for the purpose of gathering quickly data and information that would permit of a comparison of average practice with the best-known practice. Such a study, it was expected, would disclose the nature, cause and extent of preventable waste. The analysis was based on a questionnaire which had been devised for obtaining such quantitative data as the industries possessed. The work was completed in 5 months. On studying the report one is impressed with the fact that American industry is marked by preventable waste of great magnitude which if properly brought to the attention of those responsible for the financial support and commercial success of our industries would stimulate them to keener introspection and consequent improvement of their processes of production and distribution. From this point of view the report merits the careful study of financiers, business leaders, labor leaders, industrial engineers, economists and others in positions of authority and responsibility.

The sources and causes of waste in industry are attributed by the committee to: 1, low production; 2, interrupted production; 3, restricted production; 4, lost production. In seeking to place responsibility for these wastes the committee came to the conclusion that "over 50 per cent of the responsibility for these wastes can be placed at the door of the management and less than 25 per cent at the door of labor, while the amount chargeable to outside contacts is least of all. It must be recognized that if management is to meet this responsibility fully it must have the co-operation of labor."

Low production is to be ascribed mainly to faulty control of material, design and production; lack of knowledge of costs and lack of cost control; lack of research; faulty labor and sales policies. Interrupted production is a consequence of idle men whose unemployment is due to seasonal occupation, industrial depression or labor disturbances. The committee dispels a popular notion that the waste due to unemployment on account of labor disturbances is high. As a matter of fact, the amount of waste from strikes and lockouts in general is much less than is popularly supposed. Seasonal unemployment, however, is a factor of great importance in such industries as building, shoemaking and bituminous coal mining. In 1919, a year of exceptionally regular employment, the percentage of full time worked in the brick, chemical and glass industries was 85, 84 and 87 respectively. The margin of unemployment in all industry in our best years has never been less than one million men.

In restricted production due to rules and regulations of labor unions the committee finds a serious cause of waste. To the average reader many of these restrictions will appear inconceivable, affronting the intelligence of reasonable men. Lost production due to ill health and accidents is found to run into figures that are beyond comprehension, but which, nevertheless, measure the great waste arising from disease and accidents.

A chapter is devoted to the committee's recommendations for eliminating waste. Having placed a large share of the responsibility upon management, it outlines a way in which this responsibility can be met. It is largely through improvement in organization and executive control, applying sound and modern principles to production, costs, sales, purchase and personnel. Simplification and standardization of processes, equipment and products will do much to eliminate waste. Labor is held responsible for co-operation in increasing production by changing its rules that restrict output unreasonably. It is also held accountable for co-operation in the plans of management for standardization and improvement of industrial relations. The public is called upon to contribute to waste elimination by being less exacting in its demand for changes in style. The public can also assist in stabilizing industry by distributing demand in certain seasonal industries throughout the year, as in the building industry.

The committee sees an opportunity for governmental assistance through the establishment and maintenance of a national industrial information service and a national statistical service. These are functions which the Secretary of Commerce is now trying to exercise in co-operation with various industries by issuing monthly figures on production, consumption and stocks.

The industries that were investigated and on which detailed reports are made in Chapter V are building, men's clothing, shoemaking, printing, textile manufacturing and metal trades. The separate reports in these industries are accompanied by a questionnaire and the field report evaluation. While they are of particular value to the industries studied, they are suggestive to all industries and to all establishments, large or small. It is inconceivable that any manager, for example, can spend a period of serious reflection on the questionnaire, with respect to his own establishment, without having his attention directed to wasteful practices that can be changed. Indeed, this is the principal value to be gained from the widespread reading of the book.

Part III is concerned with some reports on unemployment, strikes and lockouts, legal machinery for adjusting disputes, industrial accidents, health of industrial workers, eye conservation, purchasing and sales policies. These are general summaries of available information compiled by competent critics. They have a supplementary value by emphasizing some of the causes of waste disclosed by the committee and by focusing attention on further means for solving the problem. On the whole the book represents a useful study that will be productive of further investigations and of a more critical attitude toward waste on the part of all who read it. H. C. PARMELEE.

Current Events
in the Chemical and Metallurgical Industries

Senate Sub-Committee Appointed to Investigate Dye Industry and Practices of Dye Importers

The Senate's investigation of the legislative activities of the domestic dye industry and of the practices of dye importers will be conducted by a sub-committee of the Judiciary Committee to be composed of Senator Shortridge of California, Senator Borah of Idaho and Senator Reed of Missouri. No date has been set for the hearings.

Dates Set for Rate Reduction Arguments Before Interstate Commerce Commission

Representatives of the fertilizer, sulphuric acid and phosphate rock industries will make their arguments in the rate reduction case now before the Interstate Commerce Commission on Jan. 28. Representatives of the vegetable oil and soap industries will appear on Feb. 8.

"Open Competition" Plan of Hardwood Manufacturers Association Declared Illegal

In a decision made public Dec. 19 the United States Supreme Court declared the "open competition" plan of the American Hardwood Manufacturers Association a restraint upon trade in violation of the Sherman anti-trust law. The association, consisting of 603 individuals and corporations, was charged, in the suit brought by the government, with enhancement of prices through exchange of bulletins and reports on stocks, prices and production.

Gas Leaves No Permanent Injury, Survey by C. W. S. Shows

The Chemical Warware Service has completed its survey of chemical plants and finds that the manufacturers of chlorine, heavy chemicals and other materials that produce gases similar to those used in war have no record of any permanent disability which followed the gassing of an employee.

In the research, proving development and care of the various chemicals and war gases at Edgewood Arsenal there has not been a fatal accident or permanent injury from gas since the armistice, but no week passes without one or more men being gassed to the extent of causing temporary inconvenience.

Anti-Chemical Propaganda Rife—Measures Suggested to Combat It

A country-wide propaganda apparently is on foot, which, while striking mainly at chemical warfare, shows signs of being hostile to American chemical development in general. Some profess to see behind this movement the encouragement of German dye interests, but regardless of the real source of the movement, there is evidence to show that it is being carried on in a systematic and active manner. Very material assistance is being given this effort by persons of good standing who have not taken the trouble to inquire into both sides of the chemical question. To meet this organized effort, leaders among chemists are of the opinion that it can be offset best if individual chemists throughout the country will make an effort to disseminate in their own locality the truth as to chemical warfare and to the current situation which confronts the chemical industry. There is a feeling that the domestic chemical industry has confined its attention too largely to the erection of a superstructure in Washington for which there is an insufficient base, formed by public opinion.

The whole anti-chemical movement has received great impetus from the action of the advisory committee to the American delegation at the Conference on Limitation of Armament. This report has not been made public, but it is no longer a secret that the advisory committee has recommended that chemical warfare be prohibited by international agreement. A reaction has set up in the advisory committee itself in regard to that report, it is understood. Some members of the committee now are said to feel that this report was forwarded to the commission without due consideration and it is altogether probable that it will be recalled for modification, at least.

Claims are being made widely that public opinion in the United States demands the abolition of chemical warfare. It is admitted by the friends of chemical warfare that the public has been apathetic in its attitude, but they claim that among those who have gone into the merits of the subject only an insignificant proportion believes that chemical warfare can be abolished by agreement any more than war itself can be abolished by agreement. Writers of editorials in newspapers throughout the country seem to be well advised on the subject and the overwhelming percentage not only expresses the opinion that gas has come to stay as a military weapon, but is inclined to the belief that it may be more humane than the weapons now more largely used. In that connection it may be mentioned that the controversy about gas was threshed over extensively before committees of Congress and that a deliberate conclusion in favor of gas was reached.

National Research Council's Information Service to Advise "Where to Buy"

As a part of the service to investigators generally, the Research Information Service of the National Research Council is preparing itself to supply information regarding research instruments, apparatus and supplies. This service is apparently a much needed one, for the Council is frequently receiving requests now as to where special types of apparatus or special research facilities may be procured.

It will be the effort of the information service to have available sufficient information from all sources of such equipment and supplies that it may promptly advise investigators where things needed may be quickly obtained. Some of the recent queries asked where the inquirer may purchase such things as a human skull, a selenium cell, lantern slides on European geography, a Lummer-Brodhun photometric cube, inexpensive photomicrographic apparatus, recording gages which indicate fractions of an ounce, apparatus for the study of the sensitiveness of photographic plates, and a multitude of other "specials."

In general the queries represent needs of investigators who cannot well have on hand complete files of catalogs because it is only occasionally that such special facilities are required in most small laboratories. It is hoped by the Council, therefore, that research workers generally when in doubt can be materially assisted through the complete files which it will be worth while for the Council to maintain as a part of this service. Anyone desiring information and those wishing to make sure that the facilities which they offer for sale are on record in the Council office should address Research Information Service, National Research Council, 1701 Massachusetts Ave., Washington, D. C.

Mexico to Increase Tariff Rates

On January 1 a new tariff schedule will be effective in Mexico which will increase rates on various commodities from 50 to 100 per cent. Candy, leather goods, woolens, furniture, silk, brooms and chemical products are to be taxed 50 per cent more than the present rate, while matches, soap, tobacco and toilet waters have been placed in the 100 per cent list.

PHOTO TAKEN ON STEPS ON WINANTS HALL, RUTGERS COLLEGE

Annual Meeting of the New Jersey Clay Workers' Association

The annual meeting of the New Jersey Clay Workers' Association and Eastern Section of the American Ceramic Society, held at New Brunswick, N. J., Friday, Dec. 16, surpassed in many ways any previous gathering of the organization. The papers were timely, practical and decidedly instructive; the discussions equally illuminating; and the attendance excellent.

Morning and afternoon sessions took place in the Fine Arts Room, Queen's Building, Rutgers College, and the hall was well filled when the meeting was called to order shortly after 10 o'clock, with President Abel Hansen, head of the Fords Porcelain Works, presiding.

Ceramic School Well Under Way

In his opening address President Hansen made particular reference to the new ceramic school and research station now in course of erection and which is expected to be ready for occupancy in the spring of next year. He said that the completion would mark a new milestone in the history of the ceramic industry of the state, and he urged that every support, financial and moral, be given to the enterprise.

He spoke also of the need for defined quality products in the ceramic field, and said that systematic education was necessary to bring about a full appreciation of American wares as compared with the general run of foreign production.

Brief Business Session

Secretary George H. Brown, director, department of ceramics, Rutgers College, presented an interesting report, covering the minutes of the last annual gathering as well as numerous details and features pertaining to the new school building. He mentioned the generous contributions received toward the erection of the structure from different companies in the ceramic industry, and the enterprising work of different committees appointed in this direction.

R. H. Minton, General Ceramics Co., chairman of the committee appointed to draft new bylaws for the association conforming to those of the American Ceramic Society, presented the set of rules as arranged by the committee. These were adopted by a unanimous vote, without change.

Composition of Porcelain Bodies

The first paper of the technical session was "Notes on the Effect of Composition on the Mechanical Strength of Porcelain Bodies," by Prof. Brown and C. C. Clarke, department of ceramics, Rutgers College.

The treatise set forth the results of a comprehensive series of tests of ten different porcelain bodies to determine the transverse strength of the material. The bodies were fired in regular commercial kilns, maturing at cones 7 and 8. The body compositions were varied with fundamental view of securing definite data as to the effect of the relative contents of flint and feldspar on the mechanical strength of the bodies.

The results of this work go to confirm the theory that a high flint content is conducive to greater mechanical strength. In this, however, it was pointed out that a high flint content cannot be held as being desirable for all types of porcelain bodies, and primarily, those which are subjected to wide temperature changes in use. In the latter body the gain in mechanical strength is likely to be more than offset by the tendency of the high and irregular coefficient of expansion of the flint, bringing about fracture in heating and cooling.

The high strength developed by the high feldspar body, stated at 55 per cent, has points of merit to warrant more extended investigations, and particularly so in the case of low-fire compositions, such as are used in the production of tableware and kindred specialties, and the high feldspar bodies so popular in the manufacture of vitreous floor tile.

In the high flint end of the different bodies and tests, there did not appear to be a direct relation between porosity and mechanical strength. Accordingly, it would seem that a porcelain body does not necessarily attain its maximum strength when it has developed minimum porosity.

The results of the tests were shown by illustrated references in the form of charts, flashed on the screen, the curves being plotted in a manner for ready comprehension.

Manufacture of Electrical Porcelain

The next paper was an interesting résumé of electrical porcelain manufacture by T. A. Klinefelter, Atlantic Terra Cotta Co., Tottenville, Staten Island, under the head of "Some Notes on Materials and Processes in Electrical Porcelain Manufacture."

Speaking from notes, Mr. Klinefelter showed his knowledge and intimacy of the subject by taking up each phase of production, from the raw clay to finished article. Considering briefly electrical porcelain for low-tension work, such as sockets, cutouts, fuse blocks, etc., he explained the common methods of quantity production and showed how attractive this field has become to different manufacturers.

Electrical porcelain for high-tension service, he set forth, was an entirely different proposition, requiring great care and attention in manufacture. For voltages up to 70,000 and 75,000 and above he said that ¼-in. material was the usual practice, while for 110,000 v. and even higher, ½-in. porcelain was being used. For service ranging around 40,000 v., ⅛-in. material is the customary thickness.

The material for first-grade electrical porcelain must have such characteristics as great strength, great density, great resistance to impact and resistance to severe temperature changes. Firing is carried out to cones 11 and 12 for such class of material, while for low-voltage service, burning to cones 8 and 9 answers all requirements. The usual clay mixtures for high-tension porcelain average from 40 to 60 per cent of clay, 20 to 25 per cent of feldspar and from 20 to 15 per cent of flint.

Reference was made to the different types of equipment in use. In the plant in question, regular updraft, round kilns are employed, and the speaker pointed out the indicated possibilities of tunnel kilns and compartment kilns for this work. With regard to pug mills, he said that there was great room for improvement, while diaphragm

pumps were recommended strongly for work in connection with the handling of the slip. The modern humidity drier was referred to as a great achievement, permitting the drying of ware in from 60 to 70 hours as compared with from 2 to 3 months in time gone by.

The tests made upon insulators for high line service were explained in an interesting way. In this the high frequency test is carried to voltages considerably in excess of those in standard commercial practice, sometimes running to three times above without "splashing" in attaining the "flash over" point.

An important reference made by Mr. Klinefelter covered a plea for the development of standard specifications for the purchase of clays, flint, feldspar and other raw materials, eliminating the "guess" method now prevailing. Such specifications, he said, arranged in a logical and fair-minded way, would help the purchaser, dealer and clay miner, and other parties concerned.

Nickel Salt Effect Upon Color

The concluding paper of the morning session was "The Effect of Nickel Salt on the Color," by G. M. Tucker, New York Architectural Terra Cotta Co., Long Island City.

This was a brief digest of plant experience and experiment, illustrating the uncertain quality of color reproduction in using nickel salt for terra cotta glazes. It was pointed out that it was practically impossible to utilize nickel in certain glazes for a definite color. A number of interesting specimens of work were shown.

Election of Officers

Just prior to adjournment for luncheon an election of officers was held, and the following recommendations of the nominating committee were approved for the ensuing year:

President, R. H. Minton, General Ceramics Co., Metuchen, N. J.; vice-president, Andrew Foltz, Lambertville Pottery Co., Lambertville, N. J.; councilor, Charles A. Bloomfield, Bloomfield Clay Co., Metuchen, N. J. (re-elected); and secretary and treasurer, George H. Brown, department of ceramics, Rutgers College.

The executive committee will be composed of eighteen members, in addition to the officers noted, including Abel Hansen, chairman, ex-president; August Staudt, Perth Amboy Tile Works, ex-president; and Charles Howell Cook, Cook Pottery Co., ex-president. The terms of five of the remaining fifteen members will expire in 1922; five others in 1923; and the remaining five in 1924.

Properties of Some Ball Clays

Following an hour given over to luncheon, the afternoon session was called to order by President-elect Minton close to 2:30. He made a few appropriate remarks, asking for the support of all members during his term of office. He made a plea also for increased membership during the coming year, and prior to the adjournment for the day about twenty names were added to the roster.

The afternoon technical session was opened by H. H. Sortwell, Bureau of Standards, Washington, D. C., with an interesting paper dealing with "The Properties of Some Ball Clays," illustrated with lantern slides showing different test tables.

The speaker explained the investigations now being made by the bureau of different ball clays, both of English and American origin. The properties of Kentucky clays, Tennessee clays, Dorset and other clays were enumerated, with explanation of their behavior under different tests, and the indicated desirability for certain character of manufacture.

Firebrick Manufacture

Following this, F. B. Allen, of the M. D. Valentine & Bro. Co., Woodbridge, N. J., read an illuminating paper entitled, "The Manufacture of Soft-Mud Firebrick," describing the different phases of manufacture at the Valentine plant. This factory has been operating since 1865, and has grown from one kiln to nine kilns, with rated production of approximately 600,000 firebricks per month.

Extended reference was made to recent plant improvements for increased efficiency, including the installation of considerable new machinery, such as clay granulator, disintegrator, soft-mud brick machine, mechanical driers, gravity conveyors, etc.

A Discussion on Kilns

The illness of the last speaker on the program, T. A. Shegog, ceramic chemist for the Ellis-Foster Co., Montclair, N. J., prevented the presentation of the final paper on the subject of "Principles and Practice of Kiln Firing." Accordingly President Minton gave the meeting over to a general discussion of kilns, and a valuable hour's talk ensued.

Consideration was given to tunnel kilns and compartment kilns primarily, with interesting points brought out by Mr. Minton in opening the discussion, August Staudt, T. A. Klinefelter, Leslie Brown (Lenox, Inc.), C. W. Hill (Atlantic Terra Cotta Co.), and others.

Co-operation Between Universities and Industries Discussed Before Chicago Section, A.C.S.

Dr. John Johnston, chairman of the department of chemistry, Yale University, spoke before the Chicago Section of the American Chemical Society, Dec. 16, on the question of co-operation between universities and industries. His address is outlined in the following paragraphs.

The problem of the universities is to produce men whom the industry wants, and men who will carry into industry the best spirit of advancement. It is a problem of training them to do their part in the world's work, and of developing them to the maximum of their abilities to so carry on. These men must be capable of developing new knowledge and of applying present knowledge to industry.

Teaching of chemistry in the universities does not separate these two phases. It is attempted to give some degree of industrial application of the subject as well as developing the research phase. The student cannot easily grasp a situation without some knowledge of industrial application. Industry needs a continuous supply of well-trained men, and the university is the only source of supply. Of course, industry may train men who have already had previous training, but not in proportion to its needs. Therefore, industry is the consumer.

The university must have the co-operation of industry through financial assistance and fellowships, going just as far as is compatible with the real function of the university. Each proposal to help must be judged as to whether it contributes to the training of men. It is not always possible to tell at a glance about any one proposal, but if there is any merit to it at all, it must be tried out to see if it constitutes a problem. If it is routine, it should not be done by the university.

Industry should use the university teacher as a consultant, if he is qualified by experience and doesn't take too much of his time at this work. It is advisable because it gives him connection and contact with industry and he learns to get along with people. The average college professor is too individualistic. He can never make a decision without reservations. His work as a consultant should be on a rather small scale, and he must have permission to publish his results. Research is often misnamed in industry, and the term is applied to something which is simply an artifice. This sort of research should be carried on by the industry. There is no difference between fundamental research and pure research, for industry. We are sadly lacking in fundamental knowledge as to alloys and the corrosion of metals, for instance. There is no theory now published that is worth a row of pins. The study of the mechanism of catalysis is more important than the discovery of an individual catalytic process.

One of the problems is to induce more students to stay and get a thorough training at the university. It cannot be done by giving them routine analysis as pot boilers. Where consulting work is done, consultant fees should be charged and the student should get a small part of the fee only, the rest going to the maintenance of the university department. That the professor should get part of his salary by outside work is only a partial solution of the financial situation. It does help to keep some in the teach-

ing business, and they should be allowed to consult within reason.

Fundamental research costs a great deal of money, and therefore the universities cannot finance much industrial research. Research is a form of insurance against ignorance. Industry has developed a bad opinion of the research men because many have been recommended for positions who are inadequately trained. One $10,000 a year man is worth many $2,000 a year men. So the university must discover and train $10,000 men. The university can co-operate by training this high type of man which industry needs. Since the subject of chemistry is nearly twice as large as formerly, a man cannot be adequately trained in less than 6 or 7 years at the university.

It is a well-known fact that the technical man is not considered as the highest type of professional man, both socially and otherwise. The best men who come to the universities never think of the technical professions for this reason, but they rather turn to law and medicine. This is mainly because more money is involved; but no more brains are required in law and medicine than in chemistry. The doctor and lawyer are held in much higher social esteem than the chemist.

The technical efficiency of industry is not over 50 per cent, and in many industries not over 10 per cent. Germany gets by well because the heads of concerns are technically trained men. This is true in the United States in the electrical industry only.

It is to be hoped that industry will contribute to fellowships which the universities cannot afford, and will permit them to go on a completely unrestricted basis. The publication of results within a short time is an important essential. Great benefit would be derived by an interchange of men between the industries and the universities. No university should have vocational courses.

DISCUSSION

Dr. Johnston's paper was followed by a warm discussion by both industrial and university members of the section. Dr. Evans, of Northwestern University, suggested that more students might be held in chemistry by giving them a lighter course the first year, and selling them the idea of the great benefit of chemistry in industry. Dr. David Klein, of Wilson & Co., packers, said that if industry was only on a 10 per cent basis, technically, then the universities were operating on less than a 5 per cent basis as educational institutions. He further suggested that the universities might well train their students to some knowledge of the ordinary business conditions which they would meet on leaving the university.

Production Costs in the Lithopone Industry, January-July, 1921

A study of the costs of producing lithopone during the first 6 months of 1921 shows a considerable increase over the costs during the same period of 1919. The results of this investigation, which was made by the Tariff Commission at a request of a committee representing the domestic manufacturers, have recently been published in a report by C. R. DeLong of the chemical division and E. M. Whitcomb of the accounting division of the commission's staff. The report points out that although the manufacturers reported their costs on a more uniform basis than in the previous investigation,[1] there was still a noticeable lack of uniformity in the methods of treating certain cost items. The outstanding differences are principally in the methods of handling raw material charges, determining sales expenses and in the treatment of administrative expenses.

The weighted average cost of lithopone for all companies during the first 6 months of 1921 are compared with the same 6 months' periods in 1919 in the accompanying table. This table shows also the distribution of total cost to the items—material, direct labor, factory overhead and selling expense. Column 9 shows the average profit for the industry by deducting the total cost from the average net sales price, as shown in column 8.

The increase in total cost is accounted for largely by the increase in factory overhead expense per pound of lithopone, which more than offset the decrease of 0.26 of a cent per pound in direct labor and a slight decrease in selling expense. The total cost of producing lithopone was distributed as follows: 42 per cent for raw materials, 13 per cent for direct labor, 41 per cent for factory overhead, and about 4 per cent for sales expense.

The total quantity of lithopone produced is only about one-half the output during the last half of 1919, when the industry was operating at a maximum capacity. Without doubt this restricted production is mainly responsible for the increase in total unit cost.

Only eight of the thirteen firms previously engaged in lithopone production were in actual operation during this period. Considering existing plants, the industry was in operation only to the extent of one-third of its capacity, and the eight firms which were operating manufactured lithopone equal to only about 40 per cent of their capacity. It is pointed out, however, that this inactivity is not due to competition from imported lithopone, as imports equaled only 2 per cent of domestic sales.

[1] "Barytes, Barium Chemical and Lithopone Industries, Including Costs of Production, 1919," Tariff Information Series No. 18.

German Labor Situation

From reliable sources in Germany the Department of Commerce is advised that labor unrest is again appearing in that country, concurrently with the sharp decline in the value of the German mark and advancing costs of necessary food and clothing there. Workers in the engineering and steel industries of the Düsseldorf area are now striking for increases in wage rates. It is said to be difficult to maintain operations in the most essential continuous processes of the plants at Düsseldorf. As a general average the striking workers are demanding a 75 per cent increase in wages.

In the Krupp works at Essen, employing about 50,000 men, a formal demand has just been presented to the management for a "living cost bonus" of 2,000 marks per month to each employee. A bonus is required by these workers because of the recent and continuous price advances of necessities in terms of their currency.

It is not expected that this demand of labor will remain disputed long, for it seems clearly recognized, both within and outside Germany, that the profits of manufacturers from exports are enormous, particularly while the mark is on the decline and as long as domestic costs of production lag behind the depreciation of currency.

Costs, other than labor, are already increasing, however, in marks. Railroad freights, which were advanced 30 per cent on Nov. 15, were subjected again to another 50 per cent increase on Dec. 1, thus giving a combined advance of approximately 95 per cent in a fortnight. The price of coal is shortly to be made 150 marks more per ton.

The prices of pig iron and tin plate, as of other steel products, have just been extended greatly to cover depreciation of the mark and growing costs of production. And yet foreign orders are said to be numerous, and the plant managers decline to give delivery promises under 4 months.

WEIGHTED AVERAGE COST OF LITHOPONE FOR 1919 AND FIRST 6 MONTHS 1921
(per Pound)

1	2	4	5	6	7	8	9
Period	Production (Pounds)	Total Cost	Material Cost	Direct Labor Cost	Overhead Factory	Selling Expense	Average Net Sales Price	Apparent Average Profit
1921 (First six months)	45,150,036	$0.0626	$0.0263	$0.0082	$0.0258	$0.0023	$0.0676	$0.0050
1919 (First 6 months)	53,092,739	0.0605	0.0258	0.0102	0.0215	0.0030	0.0671*	0.0066
1919 (Last 6 months)	89,426,437	0.0600	0.0259	0.0111	0.0199	0.0031	0.0653*	0.0053
1919 (12 months)	142,519,176	0.0602	0.0259	0.0108	0.0204	0.0031	0.0667*	0.0065

* Sales price for 1919 is gross price.

Professor Moureu Lectures on Rare Gases at Columbia University

Dr. Charles Moureu, professor of chemistry at the Collège de France, who is now in this country as technical adviser to the French Mission for Disarmament, delivered a very instructive address on "Natural Gases, With Special Reference to the Rare Gases," in Havemeyer Hall, Columbia University, Dec. 20.

After reviewing briefly the history of the discovery of the five rare gases—argon, neon, helium, krypton and xenon—he outlined the results of his studies on these gases as found in the atmosphere, thermal springs, firedamp and natural gases. A special apparatus for the separation and purification of the gases was illustrated and described.

A thorough study of hundreds of French thermal springs has shown an almost universal occurrence of these gases, although the quantity varies greatly with the locality, some springs having only infinitesimal amounts, while the gases from the Source Carnot of Santenay contain over 10 per cent of rare gases, helium predominating. The springs are radioactive as a rule, but the amount of radium emanation present is not proportional to the quantity of rare gases.

From numerous studies it has been shown that the proportion of rare gases in the atmosphere is fairly constant. If the ratio of the quantities of any two of the rare gases in the atmosphere is compared with the ratio for the same gases from the thermal springs, a remarkable similarity is noted. Thus if the ratio krypton:argon in air is taken as 1, the ratio krypton:argon in the gases from thermal springs does not vary much from 1. This constancy is not noted in ratios involving helium, however, because of the fact that helium is being produced by the decomposition of radium in the vicinity of radioactive springs. The ratios involving neon are being studied at the present time. Since the main constituent of the gases from thermal springs is what Prof. Moureu calls "crude nitrogen"—that is, nitrogen plus the rare gases—ratios with nitrogen were also studied and the results were fairly constant considering the relatively greater chemical activity of nitrogen. From all these observations Prof. Moureu concludes that the inert gases occur today in the same relative proportions as when the earth was formed from nebulous material.

Similar studies have been made of firedamp in the various French coal mines and of other natural gases. Prof. Moureu also touched briefly upon the work done with American natural gas and the great practical importance of these studies.

In the evening Prof. Moureu was the guest of honor at a dinner at the Chemists' Club given by the American Section of the Société de Chimie Industrielle.

"Ghosts" and Elongated Structure of Drawn Wires Discussed at Washington Chapter, A.S.S.T.

The elongated structure produced by heavy drafts in wire drawing may be readily removed by suitable annealing, whereas in the case of "ghosts" only a partial removal of this structure is effected and there remain the elongated non-metallic inclusions high in phosphorus and sulphur which pass through the grains producing lines of weakness. At a meeting of the Washington Chaper, American Society for Steel Treating, Dec. 16, the occurrences and differences between these "ghost lines" and the elongated structure produced in wire drawing were discussed by N. B. Hoffman, metallurgist of the Colonial Steel Co., Pittsburgh.

The magnitudes of the effects of "ghost lines" in low-carbon steel wire vary in individual cases, but for the numerous examples presented the tensile properties were reduced by about 26 per cent. Stead's copper reagent may be used to show the outline of the "ghosts" due to the fact that the areas low in phosphorus are first covered with copper. If the samples are washed the "ghost lines" high in phosphorus, to which the copper has not adhered, will then clearly be shown.

The January meeting of the section will be addressed by T. Holland Nelson, steel-works manager of H. Disston & Sons, Philadelphia, who will speak on "A Comparison of American and English Methods of Producing High-Grade Crucible Steel."

Number of Plants Increasing Operations Still Growing

Paper. The International Paper Co., 30 Broad St., New York, has increased production at its different mills about 100 tons daily since the first of the month, bringing the output up to about 1,000 tons per day for all varieties of paper. The company is planning for a gradual increase in manufacture to a maximum of 1,800 tons daily.

The York Haven Paper Co., York Haven, Pa., is maintaining active production at its mills, and is distributing a Christmas bonus to its 300 employees totaling about $10,000. The fund represents 5 per cent of the employees' earnings during the past 6 months.

Glass. The Scott-Warman Glass Co., East Stroudsburg, Pa., has resumed production at its plant after a considerable period of curtailment. Orders received are said to insure continuous operations for some time to come.

Rubber. The B. F. Goodrich Co., Akron, Ohio, has increased production to a point of 16,000 tires a day, or about twice the number manufactured in recent months. It is planned to advance the output gradually until a maximum of 20,000 tires daily is reached.

The Kelly-Springfield Tire Co., Cumberland, Md., has started a night shift at its local plant.

The Goodyear Tire & Rubber Co., Akron, Ohio, is operating its local plant on a basis of 16,000 tires per day.

Copper. The Raritan Copper Works of the Anaconda Copper Co., Perth Amboy, N. J., has opened a number of departments at the local plant, giving employment to an increased number of operatives.

Iron and Steel. The Logan Iron & Steel Co., Lewistown, Pa., has recently resumed operations at its puddle mills, giving employment to an increased working force.

The Bethlehem Steel Co., Bethlehem, Pa., is resuming operations in a number of departments at its Steelton, Pa., works, following an extended period of curtailment.

The Wheeling Steel Corporation has resumed full operations at its Benwood (W. Va.) tube works, giving employment to a full quota of 1,500 men. The company is also operating its top mill furnaces at 100 per cent capacity.

The Gulf States Steel Co., Gadsden, Ala., is operating at record capacity at its local plant, with full working force. New high production totals are being established.

The United Alloy Steel Corporation, Canton, Ohio, is operating on a basis of more than 50 per cent of normal, and is said to be planning for an early increase.

The American Steel Foundries, East St. Louis, Ill., is increasing production at its different plants and will be running soon at over 60 per cent of normal, as compared with 25 to 30 per cent capacity in September and October. Operations recently were resumed at the Alliance, Ohio, works, following a shutdown for several months.

The United States Steel Corporation, New York, has increased production at its various mills to about 50 per cent of normal.

Tin Plate. The McKeesport Tin Plate Co., McKeesport, Pa., is operating its forty-four mills on full time, giving employment to about 3,000 men.

The American Sheet & Tin Plate Co. has resumed full operations at its Farrell Works, Sharon, Pa., effective Dec. 18, placing six hot mills in service, making a total of thirty mills in active production at the plant.

Work of Chemical Division, Bureau of Internal Revenue

A total of 39,474 samples were analyzed by the chemical division of the Bureau of Internal Revenue during the last fiscal year, the annual report of the Commissioner which was submitted to Congress Dec. 5 shows. These samples comprised butter, oleomargarine, fats, oils, narcotic drugs, fermented beverages, distilled spirits, denatured alcohol and medicinal preparations. The laboratory work of the bureau has been greatly increased by the laws governing the administration of preparations containing alcohol. The extension of the use of alcohol free of tax has also added materially to the work of the industrial alcohol section, the report shows. The number of bonded manufacturers using specially denatured alcohol increased from 1,395 during the previous year to 1,761.

War Department Sells Sodium Nitrate

The War Department has disposed of 81,000 long tons of its reserve of sodium nitrate. The awards were made to the highest bidders for the various lots of the material located at a number of warehouses throughout the country. The prices ranged from $34.94 to $46.50 per ton. The purchasers of the larger amounts were: Hercules Powder Co., Wilmington, Del., 20,017 tons; E. I. du Pont de Nemours & Co., Wilmington, 18,600 tons; Wessel-Duval Co., New York, 18,000 tons; G. S. Alexander & Co., New York, 10,167 tons; Merrimac Chemical Co., Boston, 4,408 tons. Other purchasers were: Armour Fertilizer Works, Chicago; Equitable Powder Co., East Alton, Ill.; Senior Powder Co., Cincinnati; Southern Acid & Sulphur Co., St. Louis.

Chicago Chemists Club Night

The first evening social event of the Chicago Chemists Club's winter season occurred Saturday, Dec. 17. After dinner, served in the main dining room, the members and the ladies danced until a late hour. Novel entertainment features between the dances gave a well-rounded program.

Obituary

ROBERT H. MCKEAN, manager of the credit department of the McGraw-Hill Co., Inc., died at his home on Dec. 17, 1921, at 2 a.m. Mr. McKean's services began with *Engineering and Mining Journal* in April, 1902, as assistant in the accounting department. Within 2 years he had been promoted to the position of head bookkeeper and at the time the *Journal* was purchased by Mr. Hill he was in charge of the accounting department. About a year after the purchase of *Engineering and Mining Journal* by the Hill Publishing Co. Mr. McKean was appointed manager of the *Journal*, which position he held until he was elected a director and secretary of the Hill Publishing Co. At this time he assumed the management of the credit department of the company. He was a director and secretary of the Hill Publishing Co. until its consolidation with the McGraw Publishing Co. After the consolidation he became manager of the combined credit departments and held this position until his death. Mr. McKean's loss to the McGraw-Hill Co., Inc., will be a serious one, because of his unusual ability in his chosen work. His ready wit and keen sense of humor will be missed by his associates.

REUBEN L. LINDSTROM, superintendent Point St. Charles plant, Canadian Steel Foundries, Ltd., died on Dec. 12 at his home in Montreal. He left the Bettendorf Company, Bettendorf, Iowa, four years ago to become metallurgist with the Canadian Steel Foundries, Ltd., which position he filled until appointed superintendent of the Point St. Charles works 18 months ago.

Personal

Dr. CHARLES BASKERVILLE, professor of chemistry of the College of the City of New York, gave an address on Science and Civilization: The Rôle of Chemisty," before the members of the Pittsburgh Section of the American Chemical Society on Dec. 13.

LEWIS H. CARLSON has severed his connection with the Frederick Stearns Co. and has organized the Chemicals Sales Co., of which he is president.

HOLLIS H. DANN, recently chief chemist at Central Fe, Cuba, has become associated with the Darco Corporation, of Wilmington, Del., as technical assistant to the sales manager. Mr. Dann will have charge of the development work in connection with the cane sugar industry.

FRED C. HAHN, research chemist at the Marcus Hook plant of the National Aniline and Chemical Co., has been given a leave of absence to complete graduate work at Johns Hopkins University.

P. H. HART has been elected treasurer of the Goodyear Tire & Rubber Co., Akron, Ohio, succeeding H. H. Springford, who has become assistant to the president.

HUGH M. HENTON has resigned the instructorship in metallurgy at Case School of Applied Science, and has opened an office in the National City Building, Cleveland, Ohio, as consulting engineer in metallurgy and mining.

ARTHUR H. HUISKEN, formerly of the Baltimore Copper Works, is now with the Research Laboratory of the Edgewood Arsenal, Edgewood, Md.

ALBERT E. MARSHALL, formerly chemical engineer for the Davison Chemical Co., has severed his connection with that organization and has opened an office in Baltimore for consulting work.

Dr. H. H. MORRIS has recently resigned from the chemical department of E. I. du Pont de Nemours & Co. to take charge of the research department of the Bond Manufacturing Corporation, Wilmington, Del.

ALBERT W. SMITH, formerly dean of Sibley College, Cornell University, is now a consulting engineer with the firm of Henry R. Kent & Co., New York and Boston. Dean Smith's work will lie particularly in consultation on thermodynamic and mechanical engineering for chemical plants.

Current Market Reports

The Chemical and Allied Industrial Markets

NEW YORK, Dec. 24, 1921.

The chemical market during the past week showed no signs of any radical changes and transactions in most cases were limited to small quantities. The movement was somewhat irregular and fully in line with pre-holiday seasons. A great deal of optimism, however, is expressed by leading factors, who stated that outside influences are making for betterment in trade conditions, and with this in mind there are few indeed that do not expect an expansion in business during the early part of next year.

The export situation has also been an encouraging feature to traders and frequent inquiries are still reaching the market from various sections of Europe, the Orient and South American countries. Although actual transactions among exporters were limited, owing to the differential in quotations on spot and the prices given to exporters from their foreign customers, the fact that inquiries were freer is an encouraging sign for future prosperity. The advance in foreign exchange rates is favorable to our industry in many respects. The biggest thing that could be brought about through this advance is the opening up of export channels to permit the absorption of our surplus chemical stocks. There is also no doubt that foreign products imported to this country would bring higher prices with a stronger money market. Importations still continue with unceasing rapidity at relatively low prices and have kept the consumer from paying a price on domestic material. Adjustments are constantly taking place and it is certain that 1922 will find domestic manufacturers ready to compete in a more favorable manner than at any time since the war.

The rise of yellow prussiate of soda still continued to be the feature of the week's activities. This commodity is practically the only one to fall in line with the rise in sterling. Spot stocks seem to be well sold up and domestic producers have been turning away round lot business. Orders on hand are reported to keep factors busy far into January. On the other hand, there is an easier tone prevailing in the market on caustic soda, soda ash and caustic potash. These chemicals have become quite dormant in the past two weeks and a keener state of competition has developed. Glycerine and tin oxide have been advanced by leading makers during the week and trading in general seems to have been very satisfactory on these items. Imported chlorate of potash has also shown a little better tone, although prices are considerably lower than those quoted by domestic manufacturers. Oxalic acid is moderately active, especially in small-quantity orders to regular

consuming channels. Cream of tartar prices eased up somewhat and domestic producers announced a reduction. Quotations on the imported are close to the pre-war level, the present market holding at 25c. per lb., against 24c. for the domestic material during 1919. Yellow prussiate of potash is another item that has fallen in line with prussiate of soda and quotations were considerably higher for spot material. Stocks in resale quarters are very limited and manufacturers seem to be in a well sold up condition.

CHEMICALS

Scattered offerings of *yellow prussiate of soda* are obtainable in the open market and sellers quote from 16@16½c. per lb. The fact that imported shipments which were due to arrive late in November and in the early part of December have not shown up as yet has placed the market in very scant supply. Arrivals were quoted at 15½c per lb. c.i.f. New York, January-February shipments were held at 15½@15¾c. per lb. The present position of the market is very strong and in all probability will remain so until supplies increase. Sales of *solid caustic soda* for export have gone through at $3.80 per 100 lb. f.a.s. It was stated some business was transacted down to 3¾c. per lb. The irregular condition of the market is keeping spot quotations rather unsettled, but those closely related to the inside workings have no doubt that the market will show signs of real life early in 1922. Producers are taking on contract business over next year at $2.75 per 100 lb., basis 60 per cent, f.o.b. works. Manufacturers of *bleaching powder* reported sales at $2.25 per 100 lb., f.o.b. works, in large containers. Textile and paper mills have bought extensively during the past few weeks. The market for imported bleach is very strong and forward shipments are heavily sold as far ahead as February. Spot stocks of imported bleach are quoted at $2.20 per 100 lb. ex-dock New York. Prices on spot *oxalic acid* have been well maintained at 14½@15c. per lb. Trading is fairly active, with small lot transactions featuring. Producers quote 14@15c. per lb., f.o.b. works, depending upon the brand and quantity involved. Leading factors in domestic *chlorate of soda* quote the market at 7½c. per lb., f.o.b. works. Imported material on the spot market, however, is considerably lower, at prices ranging from 6½@6¾c. per lb. The demand is quite slow and any real business in round lots would undoubtedly bring lower quotations. *Yellow prussiate of potash* is higher and the market reflects to some extent the strength in prussiate of soda. It is very doubtful if better than 23c. per lb. can be done on this commodity, while the majority of sellers are asking all the way up to 24@25c. per lb. for only limited amounts. The red variety is also very scarce and prices range around 29c. per lb. Imported *chlorate of potash* is quoted at prices ranging from 5¾@6c. per lb. In various quarters it was intimated that the market appeared somewhat firmer at the inside quotation. The demand, however, for this chemical has been limited, since the outlet is very narrow in the face of subnormal conditions. This is preventing a rapid distribution of spot stocks, regardless of the attractive prices named. Domestic chlorate remains quotably unchanged at 12c. per lb., f.o.b. works. Imported caustic potash, 88-92 per cent, is moving very slowly and prices are irregular, with offerings heard as low as $5.40 per 100 lb. Goods on the high seas were obtainable at $5.35, while shipments were offered at 5½c. per lb. Consumers have not been purchasing any noticeable quantities during the past week and dealers stated that extreme difficulties were found to move any spot stocks. Light *soda ash* has shown very little activity on spot and dealers quote the market for domestic material at $1.90@$2 per 100 lb., in single bags, depending upon the quantity. Imported ash on dock was quoted as $1.70 per 100 lb. and shipment goods at $1.65. Barrel ash was held at $2.25@$2.30 per 100 lb. Producers continue to book contracts over next year at $1.40 per 100 lb., basis 48 per cent, f.o.b. works, in single bags. Prices on imported *sulphide of soda* have slightly declined. The demand has not shown any marked activity and second hands seemed eager to dispose of stocks at any reasonable price. Sales were reported at 4½@4¼c. per lb., for the 60-62 per cent, fused. Shipment material was held at 4¼c. per lb., duty paid, with intimations of lower prices on round lots.

The St. Louis Market

ST. LOUIS, MO., Dec. 23, 1921.

Trading in the drug and chemical markets shows little real change from the last few weeks, but if anything is a trifle slower. A few small-lot transactions have been recorded, but even in these the movement was irregular and in line with the pre-holiday season. The inventory period and holiday influences have reflected in the market operations, but only to a very small percentage.

Several advances have taken place during the last period on some of the more important items which will give a good stimulating influence for a more stable market. The heavy importations are still of great annoyance to the manufacturers and keep the market very unsettled. However, it is greatly hoped that this obstacle will soon be eliminated, and that the year 1922 will be a prosperous one.

The market on *alkalis* has declined somewhat since our last report. The demand is not great, as the flake has declined from $5.25 per 100 lb. in single drums to $4.87½, with the 12½c. differential on 5-drum lots. The carlot material has not changed. The dullness of the market is expected to cause a drop. Solid 76 per cent material is at $4 per 100 lb. in drums carlots, flakes at $4.25 per 100 lb. f.o.b. point of production. *Soda ash* has declined somewhat and can now be had at around $2.90 per 100 lb. barrels, with demand nominal. *Bicarbonate of soda* is moving slowly at about $2.50 per 100 lb., a decline of 2 to 5c. *Sal soda* is ranging around $2 per 100 lb., with the market very quiet.

CHEMICAL, DRUGS AND PHARMACEUTICALS

Acetpheneditin is moving in a fair way. Factors have again advanced their price of *acetylsalicylic acid* and a great demand is in evidence. The demand for *bromides* continues to be steady with a very firm market. Demand for *carbon bisulphide* is practically nil. *Creosote* and *guaiacols* are moving in a large way. *Glycerine* has again advanced sharply and now is in good demand at 15½c. in drums. Some contracts are still to be made, and no decline is looked for on this item for some time. Some of the *glycerophosphates* are again coming to life with quite a few inquiries and orders. *Hydroquinone* has taken an upward course and the demand is very brisk. With the rise in the sterling market manufacturers have also revised their prices on *iodides* and a general advance on all *iodide salts* took place on the 10th. *Lithium salts* continues to move quite steadily. The *salicylates* are commanding quite an important position at the present moment. There has been no change in *sulphur* and the market is very dull. *Commercial sulphur*, at $2 per 100 lb. in 25-bag lots, finds little demand. *Zinc oxide* is moving nicely and maintains the same price level of two weeks previous—that is, 7½c. in barrels, 7½c. in bags f.o.b. works for standard brands.

ACID

The heavy commercial mineral acids continue to move in a large way. *Citric acid* is not of big importance just at this time. *Pyrogallic acid* is holding its own. *Tartaric acid* has fallen off quite a bit.

VEGETABLE OILS AND NAVAL STORES

Castor oil is very firm, and the 12½c. price in drums now holds only for quantities of 200 gal. or better; for less than 200 gal. the price is 13c. for the 50-gal. drums. The *linseed oil* market is somewhat firm, and producers are taking contracts only up to May 1, the prevailing price being 70c., basis raw oil. *Turpentine* is gradually climbing and is now 85c. in single barrels, with the usual 4c. differential on 5-bbl. lots.

PAINT MATERIALS

The paint dealers, though usually overly optimistic, are showing signs of life, and some reasonably sized orders have been placed recently. *Barytes* are moving nominally at the old price of $23.50 per ton. The producers in the St. Louis lithopone market are not turning out much new material as yet, but report all their warehouse stock practically sold up, and are expecting some nice business in the future. *Whiting* can now be had in St. Louis at $12 per ton, carlots at $14.50 f.o.b. buyer's door in ton lots.

The Iron and Steel Market

PITTSBURGH, Dec. 23, 1921.

The Steel Corporation's reduction in tubular goods prices, reported a week ago, is followed this week by a reduction in wire products. In each case the reduction was brought about by price shading on the part of independent producers. In each case the reduction made makes market prices somewhat below the average of the cut prices that were ruling.

The reduction in wire products is to a schedule $5 a ton below the prices ruling prior to the advance of Sept. 12, that advance having been $2 a ton in plain wire and $3 a ton in nails and barb wire. The advance held nominally for a time, but it had been preceded by the making of 60-day contracts at the old prices, and when these contracts began to expire, last month, they were found to be renewable. The advance practically slipped away, so that the present reduction is from the old prices, not the advanced prices. The new quotations of the Steel Corporation subsidiary, the American Steel & Wire Co., were first made on Wednesday, Dec. 21, and were of course adopted by independents, being as follows: Plain wire, 2.25c.; galvanized wire, 2.75c.; wire nails, $2.50; cement coated nails, $2.15; painted barb wire, 2.65c.; galvanized barb wire, 3.15c.; polished staples, 2.65c.

The average price of wire nails in the 10 years before the war was $1.80, the low point, struck both in 1911 and in 1914, being $1.50. Thus nails are now 50 per cent above their previous low point, and it is interesting if not surprising to note that the majority of steel products show quite uniformly at the present time a price 50 per cent above the previous low price. One would, perhaps, expect more variations to be shown between commodities. Bars, shapes and plates are now quotable at 1.50c. in the case of fairly attractive orders, while in December, 1914, the going price on good-sized orders was 1c., the openly quoted market, on lots down to single carloads, being 1.05c.

LIGHT VOLUME OF BUYING

Outside of the price developments in tubular goods and wire products the steel market of the past fortnight has been practically without incident. The volume of buying has been very light, on the whole, and such buying as has occurred has been confined almost entirely to small lots, generally single carloads. All buyers have been particularly conservative in making commitments, not on account of any fresh uncertainties in the situation, but on account of the season of the year. The steel market is always very dull in the second half of December, and that rule holds good even when there is great activity in general.

PRODUCTION RATES

In October production of steel ingots was at the rate of about 23,000,000 gross tons a year, or at about 44 per cent of estimated capacity, and the Steel Corporation and independents respectively operated at very nearly the same percentage rates, in proportion to capacity. In November the Steel Corporation's operating rate increased somewhat, while the independent rate decreased correspondingly. The divergence is now much more marked, as since Dec. 1 the Steel Corporation's operations have been at above 50 per cent, and touched 55 per cent at one time, while the independents have scarcely averaged a 40 per cent rate, and production as a whole is down a trifle from the rate in October and November. A number of mills will probably close the last week of December or the first week or two of January, partly because they have made a special effort to operate lately, to furnish holiday money to employees. By the latter part of January production is likely to be nearly up to the recent rate, but no very great increase is expected for any time in the first 6 months of the new year.

PIG IRON AND COKE

Pig iron remains quotable at $20 for bessemer, $19 for basic and $19.50 for foundry, at valley furnaces, freight to Pittsburgh being $1.96.

Connellsville coke is decidedly soft, and market prices might be lower if there were enough inquiry to encourage operators to name their lowest terms. As it is, spot furnace coke is quotable nominally at $2.90@$3 and spot foundry at $3.75@$4.50, depending on brand.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	..... -	$0.40 - $0.45
Acetone	lb.	$0.12½ - $0.12½	.13 - .13½
Acid, acetic, 28 per cent	100 lbs.	2.75 - 3.00	3.25 - 3.50
Acetic, 56 per cent	100 lbs.	5.00 - 5.25	5.50 - 5.50
Acetic, glacial, 99½ per cent, carboys,	100 lbs.	10.00 - 10.50	10.75 - 11.00
Boric, crystals	lb.	.12½ - .12½	.13 - .13½
Boric, powder	lb.	.13 - .13½	.14 - .14½
Citric	lb.	..... -	.44 - .46
Hydrochloric	100 lb.	1.25 - 1.50	1.60 - 1.75
Hydrofluoric, 52 per cent	lb.	.12 - .12½	.12½ - .13
Lactic, 44 per cent tech	lb.	.09½ - .10	.10½ - .12
Lactic, 22 per cent tech	lb.	.04 - .04½	.04½ - .05
Molybdic, C.P.	lb.	3.00 - 3.25	3.30 - 3.75
Muriatic, 20 deg. (see hydrochloric)		..... -	..... - .....
Nitric, 40 deg.	lb.	.06½ - .06½	.06½ - .07
Nitric, 42 deg.	lb.	.06½ - .07	.07½ - .07½
Oxalic, crystals	lb.	.14½ - .15	.15½ - .16
Phosphoric, 50 per cent solution	lb.	.13 - .13½	.14 - .18
Picric	lb.	.20 - .25	.27 - .35
Pyrogallic, resublimed	lb.	..... -	1.65 - 1.75
Sulphuric, 60 deg., tank cars	ton	..... -	11.00 - 12.00
Sulphuric, 60 deg., drums	ton	..... -	13.00 - 15.00
Sulphuric, 66 deg., tank cars	ton	17.00 - 18.00	..... - .....
Sulphuric, 66 deg., drums	ton	21.00 - 22.00	22.50 - 23.00
Sulphuric, 66 deg., carboys	ton	..... -	..... - .....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	21.00 - 22.00	..... - .....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	23.00 - 23.50	24.00 - 24.50
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	31.00 - 32.00	33.00 - 34.00
Tannic, U. S. P.	lb.	..... -	.75 - .85
Tannic (tech.)	lb.	.55 - .60	.61 - .65
Tartaric, imported crystals	lb.	..... -	.26½ - .27
Tartaric acid, imported, powdered	lb.	..... -	.27 - .28
Tartaric acid, domestic	lb.	..... -	..... - .32
Tungstic, per lb. of WO	lb.	..... -	1.10 - 1.20
Alcohol, Ethyl	gal.	..... -	4.65 - 5.00
Alcohol, Methyl (see methanol)		..... -	..... - .....
Alcohol, denatured, 188 proof	gal.	..... -	.42 - .43
Alcohol, denatured, 190 proof	gal.	..... -	.43 - .44
Alum, ammonia, lump	lb.	.03½ - .03¾	.04 - .04½
Alum, potash, lump	lb.	.03½ - .04	.04½ - .04½
Alum, chrome lump	lb.	.08 - .08½	.08½ - .09
Aluminum sulphate, commercial	lb.	.01½ - .02	.02½ - .02½
Aluminum sulphate, iron free	lb.	.02½ - .02½	.03 - .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.07½ - .07½	.08 - .08½
Ammonia, anhydrous, cyl. (100-150 lb.)	lb.	.30 - .30½	.31 - .33
Ammonium carbonate, powder	lb.	.07 - .07½	.08 - .09
Ammonium chloride, granular (white salammoniac)	lb.	.07 - .07½	.07½ - .07½
Ammonium chloride, granular (gray salammoniac)	lb.	.07 - .07½	.07½ - .07½
Ammonium nitrate	lb.	.07½ - .07½	.07½ - .08½
Amylacetate tech	gal.	..... -	2.40 - 2.50
Arsenic oxide, (white arsenic) powdered	lb.	.06 - .06½	.06½ - .07
Arsenic, sulphide, powdered (red arsenic)	lb.	.12 - .12½	.12½ - .13
Barium chloride	ton	52.00 - 53.00	54.00 - 55.00
Barium dioxide (peroxide)	lb.	.20 - .21	.22 - .23
Barium nitrate	lb.	.06½ - .07	.07½ - .08
Barium sulphate (precip.) (blanc fixe)	lb.	.04 - .04½	.04½ - .05
Bleaching powder (see calc. hypochlorite)		..... -	..... - .....
Blue vitriol (see copper sulphate)		..... -	..... - .....
Borax (see sodium borate)		..... -	..... - .....
Brimstone (see sulphur, roll)		..... -	..... - .....
Bromine	lb.	.23 - .24	.25 - .28
Calcium acetate	100 lbs.	1.75 - 2.00	..... - .....
Calcium carbide	lb.	.04½ - .04½	.05 - .05½
Calcium chloride, fused, lump	ton	23.00 - 24.00	24.50 - 28.00
Calcium chloride, granulated	lb.	.01½ - .02	.02½ - .02½
Calcium hypochloride (bleach'g powder)	100 lb.	2.50 - 2.60	2.65 - 3.25
Calcium peroxide	lb.	..... -	1.40 - 1.50
Calcium phosphate, tribasic	lb.	..... -	.15 - .16
Camphor	lb.	..... -	.91 - .95
Carbon bisulphide	lb.	.06½ - .06½	.07 - .07½
Carbon tetrachloride, drums	lb.	.10½ - .10½	.11 - .12
Carbonyl chloride, (phosgene)	lb.	..... -	.60 - .75
Caustic potash (see potassium hydroxide)		..... -	..... - .....
Caustic soda (see sodium hydroxide)		..... -	..... - .....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.08 - .09	.09½ - .10
Chloroform	lb.	..... -	.38 - .40
Cobalt oxide	lb.	..... -	2.00 - 2.10
Copperas (see iron sulphate)		..... -	..... - .....
Copper carbonate, green precipitate	lb.	.20 - .20½	.21 - .21½
Copper cyanide	lb.	..... -	.50 - .62
Copper sulphate, crystals	100 lb.	5.65 - 5.70	5.75 - 6.25
Cream of tartar (see potassium bitartrate)		..... -	..... - .....
Epsom salt (see magnesium sulphate)		..... -	..... - .....
Ethyl Acetate Com. 85%	gal.	..... -	.70 - .80
Ethyl Acetate pure (acetic ether, 98% to 100%)	gal.	..... -	.95 - .....
Formaldehyde, 40 per cent	lb.	.10½ - .11	.11½ - .12
Fusel oil, ref.	gal.	..... -	2.50 - 3.00
Fusel oil, crude	gal.	..... -	1.50 - 1.75
Glauber's salt (see sodium sulphate)		..... -	..... - .....
Glycerine, C. P. drums extra	lb.	..... -	.16 - .16½
Iodine, resublimed	lb.	..... -	3.80 - 3.90
Iron oxide, red	lb.	..... -	.12 - .18
Iron sulphate (copperas)	ton	15.00 - 16.00	17.00 - 20.00
Lead acetate	lb.	..... -	.10½ - .12½
Lead arsenate, powd.	lb.	.15 - .15½	.15½ - .16½
Lead nitrate	lb.	..... -	.15 - .20
Litharge	lb.	.08 - .08½	.08½ - .09
Magnesium carbonate, technical	lb.	.07½ - .07½	.08 - .09
Magnesium sulphate, U. S. P.	100 lb.	2.65 - 2.70	2.75 - 3.00
Magnesium sulphate, technical	100 lb.	..... -	1.10 - 1.75
Methanol, 95%	gal.	..... -	.62 - .63
Methanol, 97%	gal.	..... -	.64 - .65
Nickel Salt, double	lb.	..... -	.12 - .12½
Nickel salt, single	lb.	..... -	.14 - .14½
Phosgene (see carbonyl chloride)		..... -	..... - .....
Phosphorus, red	lb.	.45 - .46	.47 - .50
Phosphorus, yellow	lb.	..... -	.32 - .35
Potassium bichromate	lb.	.10½ - .11	.11½ - .11½

		Carlots	Less Carlots
Potassium bitartrate (cream of tartar)	lb.	$ .... – $....	$0.25 –$0.27
Potassium bromide, granular	lb.	..... –	.15 – .20
Potassium carbonate, U. S. P	lb.	.15 – .16	.17 – .20
Potassium carbonate, 80–85%	lb.	.04½– .04¾	.05 – .06
Potassium chlorate, crystals	lb.	.06 – .06¼	.06¼– .12
Potassium cyanide	lb.	..... –	.30 – .35
Potassium hydroxide (caustic potash)	lb.	.05½– .05¾	.06 – .08
Potassium iodide	lb.	..... –	2.90 – 3.00
Potassium nitrate	lb.	.07¼– .07½	.08 – .09
Potassium permanganate	lb.	.16 – .17	.18 – .22
Potassium prussiate, red	lb.	.29 – .29½	.30 – .30½
Potassium prussiate, yellow	lb.	.23 – .23½	.24 – .25
Rochelle salts (see sodium potas. tartrate)	....	....	..... – .....
Salammoniac (see ammonium chloride)	....	....	..... – .....
Sal soda (see sodium carbonate)	....	..... –	..... – .....
Salt cake (bulk)	ton	..... –	18.00 –21.00
Silver cyanide	oz.	..... –	1.10 – 1.20
Silver nitrate	oz.	..... –	.45 – .46
Soda ash, light	100 lb.	1.75 – 2.10	2.15 – 2.50
Soda ash, dense	100 lb.	2.15 – 2.20	2.25 – 2.50
Sodium acetate	lb.	.04 – .04½	.04½– .05
Sodium bicarbonate	100 lb.	2.30 – 2.35	2.40 – 2.75
Sodium bichromate	lb.	.07½– .08	.08½– .08½
Sodium bisulphate (nitre cake)	ton	5.00 – 5.25	5.50 – 6.50
Sodium bisulphite powdered, U.S.P	lb.	.04½– .05	.05½– .06
Sodium borate (borax)	lb.	.05½– .06	.06½– .07
Sodium carbonate (sal soda)	100 lb.	1.80 – 1.90	1.95 – 2.15
Sodium chlorate	lb.	.06½– .07	.07½– .08
Sodium cyanide	lb.	.27 – .27½	.28 – .30
Sodium fluoride	lb.	.11 – .12	.12½– .14
Sodium hydroxide (caustic soda)	100 lb.	3.75 – 3.80	3.85 – 4.25
Sodium hyposulphite	lb	..... –	.03½– .03¾
Sodium nitrite	lb.	.06½– .06¾	.07 – .07½
Sodium peroxide, powdered	lb.	.25 – .26	.27 – .30
Sodium phosphate, dibasic	lb.	.04½– .04¾	.04½– .05½
Sodium potassium tartrate (Rochelle salts)	lb.	..... –	.19 – .21
Sodium prussiate, yellow	lb.	.16½– .16¾	.16½– .17
Sodium silicate, solution (40 deg.)	100 lb.	1.00 – 1.05	1.10 – 1.30
Sodium silicate, solution (60 deg.)	100 lb.	2.30 – 2.40	2.45 – 3.00
Sodium sulphate, crystals (Glauber's salt)	100 lbs.	1.30 – 1.50	1.60 – 2.00
Sodium sulphide, fused, 60–62 per cent (conc.)	lb.	.04½– .04¾	.04½– .05
Sodium sulphite, crystals	lb.	.03½– .03¾	.04 – .04½
Strontium nitrate, powdered	lb.	.11 – .12	.12½– .15
Sulphur chloride, red	lb.	.05½– .06	.06½– .06¾
Sulphur, crude	ton	18.00 –20.00	..... – .....
Sulphur dioxide, liquid, cylinders extra	lb.	.08 – .08½	.09 – .10
Sulphur (sublimed), flour	100 lb.	..... –	2.25 – 3.10
Sulphur, roll (brimstone)	100 lb.	..... –	2.00 – 2.75
Tin bichloride	lb.	.09 – .09½	.09½– .10
Tin oxide	lb.	..... –	.39 – .40
Zinc carbonate	lb.	.14 – .14½	.15 – .16
Zinc chloride, gran	lb.	.09 – .09½	.09½– .10
Zinc cyanide	lb.	.42 – .44	.45 – .47
Zinc dust	lb.	.11½– .11½	.11½– .12½
Zinc oxide, XX	lb.	.07½– .07¾	.08 – .09
Zinc sulphate	100 lb.	3.00 – 3.25	3.30 – 3.50

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude	lb.	$1.10 — $1.15
Alpha-naphthol, refined	lb.	1.25 — 1.30
Alpha-naphthylamine	lb.	.30 — .32
Aniline oil, drums extra	lb.	.17½— .19
Aniline salts	lb.	.24 — .26
Anthracene, 80% in drums (100 lb.)	lb.	.75 — 1.00
Benzaldehyde U.S.P	lb.	1.35 — 1.45
Benzidine, base	lb.	.90 — 1.00
Benzidine sulphate	lb	.75 — .85
Benzoic acid, U.S.P	lb.	.60 — .65
Benzoate of soda, U.S.P	lb.	.52 — .55
Benzene, pure, water-white, in drums (100 gal.)	gal.	.27 — .32
Benzene, 90%, in drums (100 gal.)	gal.	.25 — .28
Benzyl chloride, 95-97%, refined	lb.	.25 — .27
Benzyl chloride, tech	lb.	.20 — .23
Beta-naphthol benzoate	lb.	3.75 — 4.00
Beta-naphthol, sublimed	lb.	.70 — .75
Beta-naphthol, tech	lb.	.30 — .34
Beta-naphthyla mine, sublimed	lb.	1.65 — 1.75
Cresol, U. S. P., in drums (100 lb.)	lb.	.15 — .16
Ortho-cresol, in drums (100 lb.)	lb.	.24 — .26
Cresylic acid, 97–99%, straw color, in drums	gal.	.70 — .80
Cresylic acid, 95-97%, dark, in drums	gal.	.65 — .70
Cresylic acid, 50%, first quality, drums	gal.	.45 — .50
Dichlorbenzene	lb.	.06 — .09
Diethylaniline	lb.	.95 — 1.10
Dimethylaniline	lb.	.40 — .45
Dinitrobenzene	lb.	.23 — .27
Dinitrochlorbenzene	lb.	.20 — .25
Dinitronaphthalene	lb.	.30 — .35
Dinitrophenol	lb.	.35 — .40
Dinitrotoluene	lb.	.25 — .30
Dip oil, 25%, car lots, in drums	gal.	.30 — .35
Diphenylamine	lb.	.60 — .70
H-acid	lb.	1.00 — 1.10
Meta-phenylenediamine	lb.	1.10 — 1.15
Monochlorbenzene	lb.	.12 — .14
Monoethylaniline	lb.	1.65 — 1.70
Naphthalene crushed, in bbls	lb.	.07 — .08
Naphthalene, flake	lb.	.07 — .08
Naphthalene, balls	lb.	.08 — .09½
Naphthionic acid, crude	lb.	.70 — .75
Nitrobenzene	lb.	.12 — .15
Nitro-naphthalene	lb.	.30 — .35
Nitro-toluene	lb.	.15 — .17
Ortho-amidophenol	lb.	3.00 — 3.10
Ortho-dichlor-benzene	lb.	.15 — .20
Ortho-nitro-phenol	lb.	.77 — .80
Ortho-nitro-toluene	lb.	.15 — .20
Ortho-toluidine	lb.	.20 — .25
Para-amidophenol, base	lb.	1.40 — 1.45
Para-amidophenol, HCl	lb.	1.70 — 1.80
Para-dichlorbenzene	lb.	.12 — .15
Paranitroaniline	lb.	.77 — .80
Para-nitrotoluene	lb.	.80 — .85
Para-phenylenediamine	lb.	1.70 — 1.75
Para-toluidine	lb.	1.25 — 1.40
Phthalic anhydride	lb.	.37 — .40
Phenol, U. S. P., drums	lb.	.11½— .15
Pyridine	gal.	2.00 — 3.50
Resorcinol, technical	lb.	1.50 — 1.60
Resorcinol, pure	lb.	2.00 — 2.25
Salicylic acid, tech., in bbls	lb.	.20 — .21
Salicylic acid, U. S. P	lb.	.22 — .23
Salol	lb.	.70 — .72
Solvent naphtha, water-white, in drums, 100 gal	gal.	.25 — .28
Solvent naphtha, crude, heavy, in drums, 100 gal	gal.	.14 — .16
Sulphanilic acid, crude	lb.	.27 — .30
Toluidine	lb.	1.30 — 1.35
Toluidine, mixed	lb.	.43 — .45
Toluene, in tank cars	gal.	.25 — .28
Toluene, in drums	gal.	.28 — .31
Xylidines, drums, 100 gal	lb.	.40 — .45
Xylene, pure, in drums	gal.	.40 — .45
Xylene, pure, in tank cars	gal.	.45 — ....
Xylene, commercial, in drums, 100 gal	gal.	.33 — .35
Xylene, commercial, in tank cars	gal.	.30 — ....

Waxes

Prices based on original packages in large quantities.

Bayberry Wax	lb.	$0.21 — $0.22
Beeswax, refined, dark	lb.	.24 — .25
Beeswax, refined, light	lb.	.28 — .30
Beeswax, white pure	lb.	.34 — .38
Candellila wax	lb.	.24 — .24½
Carnauba, No. 1	lb.	.45 — .46
Carnauba, No. 2, North Country	lb.	.23½— .24
Carnauba, No. 3, North Country	lb.	.13½— .14
Japan	lb.	.21 — .21½
Montan, crude	lb.	.04½— .05
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.04½— .04½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.03½— ....
Paraffine waxes, refined, 118-120 m.p.	lb.	.03½— .04
Paraffine waxes, refined, 125 m.p.	lb.	.04 — .04½
Paraffine waxes, refined, 128-130 m.p.	lb.	.04½— .04½
Paraffine waxes, refined, 133-135 m.p.	lb.	.05 — .05½
Paraffine waxes, refined, 135-137 m.p.	lb.	.05½— .05½
Stearic acid, single pressed	lb.	.09½— ....
Stearic acid, double pressed	lb.	.09½— ....
Stearic acid, triple pressed	lb.	.10½— .10½

Naval Stores

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Rosin B-D, bbl	280 lb.	$5.30 —	5.35
Rosin E-I	280 lb.	5.40 —	5.50
Rosin K-N	280 lb.	6.05 —	6.75
Rosin W. G.-W. W	280 lb.	7.00 —	7.25
Wood rosin, bbl	280 lb.	6.25 —	.....
Spirits of turpentine	gal.	.81 —	.....
Wood turpentine, steam dist	gal.	.79 —	.....
Wood turpentine, dest. dist	gal.	.78 —	.....
Pine tar pitch, bbl	200 lb.	..... —	6.00
Tar, kiln burned, bbl. (500 lb.)	bbl.	..... —	9.50
Retort tar, bbl	500 lb.	—	9.50
Rosin oil, first run	gal.	.36 —	.....
Rosin oil, second run	gal.	.39 —	.....
Rosin oil, third run	gal.	.46 —	.....
Pine oil, steam dist., sp.gr., 0.930-0.940	gal.		$1.90
Pine oil, pure, dest. dist	gal.		1.50
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.		.46
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla	gal.		.35
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.		.75
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.		.35
Turpentine, crude, sp. gr., 0.900-0.970	gal.		1.25
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.		.35
Pinewood creosote, ref	gal.		.52

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.37
70-72 deg., steel bbls. (85 lb.)	gal.	.35
68-70 deg., steel bbls. (85 lb.)	gal.	.34
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23

Fertilizers

Ammonium sulphate, bulk and d. bags	100 lb.	$2.30 —	2.90
Blood, dried, f.o.b., N. Y	unit	4.00	
Bone, 3 and 50, ground, raw	ton	30.00 —	32.00
Fish scrap, dom., dried, f.o.b. works	unit	2.90 —	3.00
Nitrate soda	100 lb.	2.30 —	2.35
Tankage, high grade, f.o.b. Chicago	unit	2.75 —	3.00
Phosphate rock, f.o.b. mines, Florida pebble, 68-72 p.c	ton	4.50 —	6.50
Tennessee, 78-80 p.c	ton	8.50 —	9.00
Potassium muriate, 80 p.c	ton	34.00 —	35.00
Potassium sulphate	unit	.90 —	1.00

Crude Rubber

Para—Upriver fine	lb.	$0.23 —	.23½
Upriver coarse	lb.	.13½—	.14
Upriver caucho ball	lb.	.13 —	.13½
Plantation—First latex crepe	lb.	.18½—	.18½
Ribbed smoked sheets	lb.	.18½—	.19
Brown crepe, thin, clean	lb.	.15 —	.....
Amber crepe No. 1	lb.	.17½—	.....

Oils

VEGETABLE

The following prices are f.o.b. New York for carload lots.

Castor oil, No. 3, in bbls	lb.	$0.10½—	$0.10½
Castor oil, AA, in bbls	lb.	.11½—	.12
China wood oil, in bbls. (f.o.b. Pac. coast)	lb.	.13½—	.13½
Cocoanut oil, Ceylon grade, in bbls	lb.	.09 —	.09½
Cocoanut oil, Cochin grade, in bbls	lb.	.10 —	.10½
Corn oil, crude, in bbls	lb.	.08½—	.08½
Cottonseed oil, crude (f. o. b. mill)	lb.	.07 —	.07½
Cottonseed oil, summer yellow	lb.	.08½—	.09
Cottonseed oil, winter yellow	lb.	.09½—	.09½

Linseed oil, raw, car lots (domestic)	gal.	.67 —	.68
Linseed oil, raw, tank cars (domestic)	gal.	.62 —	.63
Linseed oil, in 5-bbl lots (domestic)	gal.	.70 —	.71
Olive oil, Denatured	gal.	$1.15 —	$1.20
Palm, Lagos	lb.	.07½ —	.07¾
Palm, Niger	lb.	.06½ —	.06¾
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.08 —	.08¼
Peanut oil, refined, in bbls	lb.	.11 —	.11¼
Rapeseed oil, refined in bbls	gal.	.82 —	.83
Rapeseed oil, blown, in bbls	gal.	.88 —	.90
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.08¾ —	....
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.07½ —	....
FISH			
Light pressed menhaden	gal.	$0.43 —	....
Yellow bleached menhaden	gal.	.44 —	....
White bleached menhaden	gal.	.46 —	....
Blown menhaden	gal.	.48 —	....

Miscellaneous Materials

All f.o.b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$23.00 —	23.50
Barytes, ground, off color, f.o.b. Kings Creek	net ton	15.00 —	17.00
Barytes, crude, 88%@94% ba., Kings Creek	net ton	10.00 —	12.00
Barytes, floated, f.o.b. St. Louis	net ton	23.00 —	24.00
Barytes, crude, first grade, Missouri	net ton	6.00 —	7.00
Blanc fixe, dry	lb.	.04 —	.04½
Blanc fixe, pulp	net ton	45.00 —	55.00
Casein	lb.	.14 —	.14½
Chalk, Precipitated, domestic, extra light	lb.	.04½ —	.05
Chalk, Precipitated, domestic, light	lb.	.04 —	.04½
Chalk, Precipitated, domestic, heavy	lb.	.03½ —	.04
Chalk, Precipitated, English, extra light	lb.	.04½ —	.05
Chalk, Precipitated, English, light	lb.	.04½ —	.05
Chalk, Precipitated, English, dense	lb.	.04 —	.04½
China clay (kaolin) crude, f.o.b. mines, Georgia	net ton	6.50 —	8.50
China clay (kaolin) washed, f.o.b. Georgia	net ton	9.00 —	10.00
China clay (kaolin) powdered, f.o.b. Georgia	net ton	13.00 —	20.00
China clay (kaolin) crude f.o.b. Virginia points	net ton	8.00 —	12.00
China clay (kaolin) ground, f.o.b. Virginia points	net ton	13.00 —	20.00
China clay (kaolin), imported, lump	net ton	12.00 —	20.00
China clay (kaolin), imported, powdered	net ton	25.00 —	30.00
Feldspar, crude, f.o.b. Maryland and North Carolina points	net ton	5.00 —	7.50
Feldspar, crude, f.o.b. Maine	net ton	7.50 —	10.00
Feldspar, ground, f.o.b. Maine	net ton	21.00 —	23.00
Feldspar, ground, f.o.b. North Carolina	net ton	17.00 —	21.00
Feldspar, ground, f.o.b. N. Y. State	net ton	17.00 —	21.00
Feldspar, ground, f.o.b. Baltimore	net ton	27.00 —	30.00
Fullers earth, f.o.b. Miles	net ton	16.00 —	17.00
Fullers earth, granular, f.o.b. Fla	net ton	15.00 —	16.00
Fullers earth, powdered, f.o.b. Fla	net ton	18.00 —	....
Fullers earth, imported, powdered	net ton	22.00 —	24.00
Graphite, Ceylon lump, first quality	lb.	.05½ —	.06½
Graphite, Ceylon chip	lb.	.04 —	.05
Graphite, high grade amorphous crude	lb.	.00½ —	.02½
Kieselguhr, f.o.b. mines, Cal.	per ton	40.00 —	....
Kieselguhr, f.o.b. N.Y.	per ton	55.00 —	60.00
Magnesite, calcined	per ton	50.00 —	65.00
Pumice stone, imported	lb.	.03 —	.40
Pumice stone, domestic, lump	lb.	.05 —	.05½
Pumice stone, domestic, ground	lb.	.06 —	.07
Quartz (acid tower) first to head, f.o.b. Baltimore	net ton	.... —	10.00
Quartz (acid tower) 1½@2 in., f.o.b. Baltimore	net ton	.... —	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	.... —	17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00 —	7.50
Shellac, orange fine	lb.	.68 —	.70
Shellac, orange superfine	lb.	.78 —	.80
Shellac, A. C. garnet	lb.	.58 —	.60
Shellac, T. N.	lb.	.68 —	.70
Soapstone	ton	15.00 —	17.00
Sodium chloride	long ton	12.50 —	13.00
Talc, paper-making grades, f.o.b. Vermont	ton	11.00 —	18.00
Talc, roofing grades, f.o.b. Vermont	ton	8.25 —	13.00
Talc, rubber grades, f.o.b. Vermont	ton	11.00 —	18.00
Talc, powdered, Southern, f.o.b. cars	ton	7.50 —	11.00
Talc, imported	ton	30.00 —	40.00
Talc, California talcum powder grade	ton	18.00 —	25.00

Refractories

Bauxite brick, 56% Al, f.o.b. Pittsburgh	per ton		$50.00
Carborundum refractory brick, 9-in. — less than carlot	1,000		1250.00
Carborundum refractory brick, 9-in. — carlond lots	1,000		1100.00
Chrome brick, f.o.b. Eastern shipping points	net ton		52- 55
Chrome cement, 40-45% Cr_2O_3	net ton		30- 32
Chrome cement, 40-45% Cr_2O_3, sacks, in car lots, f.o.b. Eastern shipping points	net ton		33- 35
Fireclay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000		35- 40
Fireclay brick, 2nd quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000		30- 35
Magnesite brick, 9-in. straight	net ton		65- 70
Magnesite brick, 9-in. arches, wedges and keys	net ton		77
Magnesite brick, soaps and splits	net ton		98
Silica brick, 9-in. sizes, f.o.b Chicago district	1,000		40- 42
Silica brick, 9-in. sizes, f.o.b. Birmingham district	1,000		42- 45
Silica brick, 9-in. sizes, f.o.b. Mt. Union, Pa	1,000		35- 38

Ferro-Alloys

All f.o.b. Works

Ferrocarbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$225.00
Ferrochrome per lb. of Cr. contained, 6-8% carbon, carlots	lb.	.12 —	....
Ferrochrome, per lb. of Cr. contained, 4-6% carbon, carlots	lb.	.13 —	....
Ferromanganese, 76-80% Mn, domestic	gross ton	58.00 —	60.00
Ferromanganese, 76-80% Mn, Foreign, C. I. F. Atlantic Seaport	gross ton	54.00 —	58.35
Spiegeleisen, 18-22% Mn	gross ton	25.00 —	27.00
Ferromolybdenum, 50-60% Mo, per lb. of Mo	lb.	2.25 —	....
Ferrosilicon, 10-15%	gross ton	38.00 —	40.00
Ferrosilicon, 50%	gross ton	57.00 —	59.00
Ferrosilicon, 75%	gross ton	120.00 —	125.00
Ferrotungsten, 70-80%, per lb. of contained W	lb.	.40 —	.45
Ferrouranium, 35-50% of U, per lb.of U content	lb.	6.00 —	....
Ferrovanadium, 30-40% per lb. of contained V.	lb.	4.25 —	4.50

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al content	net ton	$8.00 —	$10.00
Chrome ore, Calif. concentrates, 50% min. Cr_2O_3	ton	22.00 —	23.00
Chrome ore, 50% Cr_2O_3, f.o.b. Atlantic seaboard	ton	22.00 —	23.00
Coke, foundry, f.o.b. ovens	net ton	4.25 —	4.50
Coke, furnace, f.o.b. ovens	net ton	3.25 —	3.50
Fluorspar, gravel, f.o.b. mines, New Mexico	net ton	12.00 —	....
Fluorspar, standard, domestic washed gravel Kentucky and Illinois mines	net ton	20.00 —	22.00
Ilmenite, 52% TiO_2, per lb. ore	lb.	.01½ —	.01¾
Manganese ore, 50% Mn, c.i.f. Atlantic seaport	unit	.23 —	.24
Manganese ore, chemical (MnO_2)	net ton	55.00 —	60.00
Molybdenite, 85% MoS_2, per lb. of MoS_2, N. Y.	lb.	.45 —	.50
Monazite, per unit of ThO_2, c.i.f., Atlantic seaport	unit	30.00 —	....
Pyrites, Spanish, fines, c.i.f., Atlantic seaport	unit	.12 —	.12
Pyrites, Spanish, furnace size, c.i.f. Atlantic seaport	unit	.13 —	.13
Pyrites, domestic, fines, f.o.b. mines, Ga.	unit	.11 —	.12
Rutile, 95% TiO_2 per lb. ore	lb.	.15 —	....
Tungsten, scheelite, 60% WO_3 and over, per unit of WO_3 (nominal)	unit	2.50 —	2.75
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3, N. Y. C.	unit	2.75 —	3.00
Uranium ore (carnotite) per lb. of U_3O_8	lb.	1.25 —	1.75
Uranium oxide, 96% per lb. contained U_3O_8	lb.	2.25 —	2.50
Vanadium pentoxide, 99%	lb.	12.00 —	14.00
Vanadium ore, per lb. of V_2O_5 contained	lb.	1.00 —	....
Zircon, washed, iron free, f.o.b. Pablo, Florida	lb.	.04½ —	.13

Non-Ferrous Metals

New York Markets

	Cents per Lb.
Copper, electrolytic	13.875
Aluminum, 98 to 99 per cent.	19.00
Antimony, wholesale lots, Chinese and Japanese	4.50
Nickel, ordinary (ingot)	41.00
Nickel, electrolytic	44.00
Monel metal, shot and blocks	35.00
Monel metal ingots	38.00
Monel metal, sheet bars	40.00
Tin, 5-ton lots, Straits	32.875
Lead, New York, spot	4.70
Lead, E. St. Louis, spot	4.375
Zinc, spot, New York	5.30@5.35
Zinc, spot, E. St. Louis	4.85@4.90

OTHER METALS

Silver (commercial)	oz.	$0.65½
Cadmium	lb.	1.00–1.25
Bismuth (500 lb. lots)	lb.	1.50@1.55
Cobalt	lb.	3.00@3.25
Magnesium (f.o.b. Philadelphia)	lb.	1.25
Platinum	oz.	75.00–78.00
Iridium	oz.	150.00@170.00
Palladium	oz.	55.00–60.00
Mercury	75 lb.	51.00–52.00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	21.25
Copper bottoms	28.75
Copper rods	19.75
High brass wire	17.25
High brass rods	14.75
Low brass wire	18.75
Low brass rods	19.25
Brazed brass tubing	25.50
Brazed bronze tubing	30.50
Seamless copper tubing	21.25
Seamless high brass tubing	18.50

OLD METALS—The following are the dealers' purchasing prices in cents per pound:

	New York Current	Cleveland	Chicago
Copper, heavy and crucible	9.75@10.25	9.25	9.50
Copper, heavy and wire	9.25@9.50	8.50	8.50
Copper, light and bottoms	7.50@8.00	7.50	7.25
Lead, heavy	3.50@3.75	3.25	3.25
Lead, tea	2.25@2.35	2.25	2.25
Brass, heavy	4.25@4.50	4.50	5.00
Brass, light	3.25@3.50	3.25	3.50
No. 1 yellow brass turnings	4.00@4.25	4.25	4.50
Zinc	2.00@2.25	2.00	2.25

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by ¼ in. and larger, and plates ¼ in. and heavier, from jobbers' warehouses in the cities named:

	New York	Cleveland	Chicago
Structural shapes	$2.78	$2.88	$2.78
Soft steel bars	2.68	2.78	2.68
Soft steel bar shapes	2.68	2.78	2.68
Soft steel bands	3.28	3.48	3.28
Plates, ¼ to 1 in. thick	2.78	2.88	2.78

*Add 15c per 100 lb. for trucking to Jersey City and 10c for delivery in New York and Brooklyn

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

BIRMINGHAM—The Acme Oil Co. of Alabama, recently organized, has had plans prepared for the erection of a local oil works, with initial daily capacity of about 3,000 gal. D. E. Chandler is secretary.

California

SACRAMENTO—The Sacramento Brick Co. is planning for the installation of additional machinery at its plant to develop an annual capacity of about 30,000,000 bricks. The company will also establish a department for the manufacture of roofing tile and other ceramic products. H. H. Bartells is manager.

Georgia

BRUNSWICK—The Ocean Leather Co, 33 New York Ave., Newark, N. J., is perfecting plans for the establishment of a plant at Brunswick for the tanning of shark skins and other fish hides. Alfred Ehrenreich is president.

Florida

JACKSONVILLE — The Florida-Louisiana Refining Co., now being organized with a capital of $500,000, is planning for the erection of a large oil refinery on local site. H. C. Leete, Jacksonville, heads the organization.

MIAMI—The Pennsylvania Sugar Co., Delaware Ave., Philadelphia, Pa., has acquired a tract of land adjoining its property in this section, totaling about 60,000 acres, and plans to use the portion of the site for a new sugar mill, estimated to cost close to $500,000, including machinery.

Illinois

HILLSBORO—Fire, Dec. 7, destroyed a portion of the plant of the Schram Glass Mfg. Co., with loss reported at close to $30,000.

ROCKFORD — The Hess & Hopkins Leather Co. is considering tentative plans for the rebuilding of its 1-story plant, 60 x 115 ft., and proposes to commence work early in the spring. F. L. Morgan is secretary.

CHICAGO—The city of Chicago, architect Charles W. Tallal, is preparing plans for a 2-story pumping station to be erected near Western Ave. and 43d St., in connection with the Western Ave. water tunnel; estimated cost $3,165,000. The beginning of the work will be dependent upon the appropriation of the 1922 city of Chicago budget.

CHICAGO — The Cole Storage Battery Co., located at 2437 Indiana Ave., is preparing plans for a 1-story addition to its present factory; estimated cost $30,000.

CHICAGO—The Dental Metal Products Co. is preparing plans for a 2-story mill construction factory, 42x71 ft., and a warehouse 28x42 ft. for the manufacture of dental products. This plant will be located at 7512 Greenwood Ave.; estimated cost $30,000.

Indiana

INDIANAPOLIS—The Piel Bros. Starch Co., State Life Bldg., is planning for the construction of a 1-story top addition to its plant, 200 x 200 ft. Improvements will be made also in the present plant. The work is estimated to cost about $50,000. William F. Piel is president.

Louisiana

SHREVEPORT—The United States Sheet & Window Glass Co. is pushing construction on its new local works and expects to occupy the plant at an early date. It is estimated to represent an investment of close to $1,000,000. It is reported that further additions will be made in the near future.

ALEXANDRIA—W. J. O'Pry, Alexandria, and associates are organizing a new company to establish a local tannery. A building has been purchased for the works, and occupancy will be arranged at an early date.

Maryland

BALTIMORE—The Union Smelting & Refining Co., Charles St., Newark, N. J., has acquired the property at Ostend and Howard Sts., 135 x 155 ft., for a consideration said to be $31,000. It is proposed to use the site for the erection of a branch plant.

CENTERVILLE—E. S. Valliant & Son, manufacturers of fertilizer products, are arranging for the removal of a portion of their business, now located at Church Hill, and purpose to make Centerville their headquarters. The company operates a large fertilizer plant at Centerville Landing, and will concentrate production to a large extent at this point.

Massachusetts

SALEM—The Park Leather Co., Grove St., has awarded a contract to A. C. Brown, Danvers, Mass., for extensions and improvements in its plant. The work will be commenced at once.

Michigan

SHEBOYGAN—The Union Bag & Paper Co. has work under way on the remodeling of its plant 3-story 60 x 100 ft. estimated to cost about $100,000. The improvement is being arranged for increased operations and better efficiency in production. G. S. Witham is general superintendent.

DETROIT — The Gagnier Stereotype Foundry Co., 525 Howard Ave., is having plans prepared for the erection of a new 1-story foundry on McKinistry St., estimated to cost about $50,000. Kasurin Bros., 512 Empire Bldg., are architects. Edmond Gagnier is president.

PONTIAC—The Crodius Steam Pressed Brick Co. has tentative plans under consideration for the construction of a new plant. It is proposed to inaugurate work in the spring of the coming year. C. J. Crawford is president.

OTSEGO—The Mac-Sim-Bar Paper Co. has taken bids for the erection of the proposed new 1-story electric power plant at its mill, to be used for general operating service. It will be 80 x 140 ft., and is estimated to cost close to $300,000, including machinery. Billingham & Cobb, Press Bldg., Kalamazoo, are architects.

PORT HURON—The Port Huron Sulphite & Paper Co., 1805 Richardson St., has construction under way on a 2-story and basement addition to its plant on Black River St., 70 x 100 ft., estimated to cost about $50,000. Alfred J. L. Sullivan, 1320 Tenth St., has received the building contract. Edgar Kiefer is president.

Montana

CUT BANK—The Cut Bank Flour Mill Co. is reported to be planning for the rebuilding of the portion of its local plant, recently destroyed by fire with loss estimated at about $35,000. John Bye is manager.

BAINVILLE—Fire recently destroyed a portion of the flour mill and elevator of the Jennison Mills Co. An official estimate of loss has not been made. It is said that the plant will be rebuilt at once.

New Jersey

METUCHEN—The General Ceramics Co., 50 Church St., New York, has perfected plans for the immediate erection of the proposed addition to its local sanitary ware manufacturing plant, estimated to cost about $100,000. Dietrich Wertmann, 118 Lexington Ave., New York, is architect.

MATAWAN—Fire, Dec. 16, destroyed a portion of the plant of the Erdman Color Works and the adjoining factory of the Chrome Color Works, operated by the same interests, with loss estimated at about $85,000, including machinery.

NEWARK—The Miller Oil Products Co., Bloomfield, N. J., has acquired property at 33-39 Ave. A, extending to 135-39 Miller St., for the manufacture of oils, polishes, etc. The lease covers a long term and the company will remove its plant to this location shortly after the first of January. The property comprises a 1-story building, on a lot totaling 100 x 150 ft. A number of improvements are planned.

GARFIELD—Fire, Dec. 12, destroyed a large portion of the plant of the Heyden Chemical Co. of America, Monroe St. and River Road, with loss estimated at close to $500,000, including machinery. S. H. Chamberlain is president.

ELIZABETH—Fire, Dec. 10, destroyed a portion of the plant of the Darvin Chemical Co., with loss estimated at close to $75,000. The plant is located on Miller St., and it is proposed to rebuild at an early date.

New York

HUDSON—The Hudson City Steel Co., 233 Broadway, New York, has preliminary plans under way for the erection of a new steel works at Hudson. It is proposed to call for bids early in the spring. Dwight P. Robinson & Co., 125 East Forty-sixth St., New York, are engineers.

North Carolina

LENOIR—T. H. Broyhill and F. H. Coffey, Lenoir, are organizing a new company with capital of $200,000, for establishment of a local plant for the manufacture of mirrors and other glassware products.

Ohio

CINCINNATI — The Ultra-Marine Co., Huntington, W. Va., manufacturer of bluing, etc., has plans under way for the erection of a 1-story and 2-story plant on site selected at Cincinnati. It is proposed to call for bids late in February. E. C. Baugher is superintendent.

Pennsylvania

JAMISON CITY—The Elk Tanning Co. has construction under way on an addition to its plant, to include a 1-story extension to the beam house. The capacity will be increased.

PHILADELPHIA—F. W. Tunnell & Co., 15 North Fifth St., manufacturers of glue, fertilizers, etc., have filed plans for the erection of a 1-story plant extension.

MARCUS HOOK—The Viscose Co., has work well under way on a 3-story and basement addition to its local plant, estimated to cost about $150,000. It is planned to occupy the structure for general manufacture at an early date.

Tennessee

CHATTANOOGA — The Independent Glass Co. has awarded a contract to J. W. Pogue, Chattanooga, for the erection of a new 2-story plant, 50 x 195 ft., to be equipped for the manufacture of windshields and other glass products. A. R. Williams is president.

KNOXVILLE—The Knoxville Fertilizer Co. is completing foundations for its new plant in the Vestal section, and will commence the immediate erection of the superstructure. The plant, with equipment, is estimated to cost about $200,000. J. W. Dean is secretary and treasurer.

BRISTOL—A. D. Reynolds, Bristol and Leroy Park, Greenville, Tenn., are organizing a new company to construct and operate a blast furnace and steel works on a site being selected in eastern Tennessee. It is said that the new plant will cost in excess of $500,000.

Texas

COLEMAN—J. P. Morris has acquired the local plant of the Brinkley Brick & Tile Co. The new owner purposes to operate the works, and is said to be planning for a number of extensions and improvements.

DALLAS—The O. C. China Novelty & Pottery Co., 1104-6 South Betterton St., has filed plans for the erection of a new 2-story and basement plant, estimated to cost about $25,000.

HOUSTON—The Humphreys-Pure Oil Co. is reported to be planning for the erection of a new local refinery, with initial capacity of about 30,000 bbl. of oil a day. The refining plant will be operated in connection with the proposed pipe line to be constructed from Mexia, Tex., to the Gulf. The entire project is estimated to cost in excess of $1,000,000. Col. E. A. Humphreys is president.

CORSICANA—The Corsicana Oil & Refining Co., is planning for the immediate operation of its new local oil refinery, now practically completed. It will be run on a full capacity basis.

Virginia

RICHMOND — The Virginia-Carolina Rubber Co., North Nineteenth Street, will break ground at once for the erection of a new 1-story plant, estimated to cost about $130,000, and of which amount approximately $90,000 will be used for the purchase of new machinery and equipment. R. J. Bell is manager.

New Companies

THE PHARMO CHEMICAL CO., Newark, N. J., has been incorporated with a capital of $50,000, to manufacture chemicals and chemical byproducts. The incorporators are Samuel W. Barlow and Harry S. Neiwirth, 63 New Jersey Railroad Ave., Newark.

THE SOUTH WILLIAMSPORT TANNING CO., South Williamsport, Pa., has been incorporated with a capital of $24,000, to manufacture leather products. L. R. Plankenhorn, South Williamsport, is treasurer.

THE BOLIVAR REFINING CORP., Bolivar (Allegeny County), N. Y., has been incorporated with a capital of $350,000, to manufacture refined oil products. The incorporators are H. B. Yerdon, W. E. Sawyer and C. A. Chipman. The company is represented by Bliss & Bliss, Bolivar.

THE CAROLINA FISH & OIL CO., Moorhead City N. C., has been incorporated with a capital of $100,000, to manufacture oil products of various kinds. The incorporators are D. W. Wade, E. H. Gorham and J. E. Woodland, Moorhead City.

THE CHICAGO CORE COMPOUND CO., 302 Marquette Bldg., Chicago, Ill., has been incorporated with a capital of $10,000, to manufacture chemicals, compounds, etc. The incorporators are W. W. Welch, William A. Herron and Thomas G. Lovelace.

THE STANDARD APPROVED PRODUCTS CO., Washington, D. C., has been incorporated under Delaware laws with capital of $750,000, to manufacture tile, fire-proofing cement and kindred specialties. The incorporators are Albert Pauley, R. J. Michael and Joseph F. Randall, Washington. The company is represented by Horace G. Eastburn, Ford Bldg., Wilmington, Del.

THE NEW YORK FELDSPAR CORP., Rochester, N. Y., has been incorporated with a capital of $100,000, to operate a feldspar producing and grinding plant. The incorporators are F. G. Kennedy and J. W. B. Bausman. The company is represented by Havens, Mann, Strang & Whipple, attorneys, Rochester.

THE COMMONWEALTH OIL CORP., Union Hill, N. J., has been incorporated with a capital of $100,000, to manufacture oil products. The incorporators are W. Stanley Coles, George and Herman Koch, 101 Bergenline Ave., Union Hill.

THE MOORE-NORTH RUBBER CO., Fort Worth, Tex., has been organized under state laws to manufacture rubber specialties. The company is headed by J. W. Moore, E. M. North and E. E. Edgar, Fort Worth.

THE MIDWEST GLASS PRODUCTS CO., 112 South Michigan Ave., Chicago, Ill., has been incorporated with a capital of $500,000, to manufacture glassware of various kinds. The incorporators are O. S. Flath, C. R. W. Peterson and Otto Treulich.

THE ADAMANT RUBBER PRODUCTS CO., New York, N. Y., has been incorporated with a capital of $500,000, to manufacture rubber goods of various kinds. The incorporators are M. Stabins and B. Weiner. The company is represented by M. P. Schaffer, 1463 Broadway, New York.

THE CITY BRICK CO., Los Angeles, Cal., has been incorporated with a capital of $100,000, to manufacture brick and other burned clay products. The incorporators are W. R., J. T., and I. L. Simons. The company is represented by Ford & Bodkin, 410 H. W. Hellman Bldg., Los Angeles.

MCKECHNIE BROS., INC., Philadelphia, Pa., has been incorporated with a capital of $150,000, to operate a metal smelting and refining plant. William McKechnie, Bellevue-Stratford Hotel, Philadelphia, is treasurer.

THE ZIRALOY CO., 1227 Calvert Bldg., Baltimore, Md., has been incorporated with a capital of $50,000, to manufacture metals and metal alloys. The incorporators are Robert E. L. Young and Fredinand I. Gruebel.

THE NOX-A-MITE CHEMICAL CO., 417 South Dearborn St., Chicago, Ill., has been organized under state laws to manufacture chemicals and chemical byproducts. The incorporators are William F. Ayres, Charles E. Ludington and John F. Gallagher.

THE AMERICAN OIL CO., Hattiesburg, Miss., has been incorporated with a capital of $100,000, to manufacture petroleum products. The incorporators are A. R. Harbison, J. O. Barron and James A. Swayne, Hattiesburg.

THE NATIONAL FIBREFORM CO., Wilmington, Del., has been incorporated under state laws with capital of $500,000, to manufacture fiber and pulp products. The company is represented by the Corporation Trust Co. of America, du Pont Bldg., Wilmington.

THE EVANSVILLE OIL & GREASE CO., Evansville, Ind., has been incorporated with a capital of $200,000, to manufacture oils, greases and other lubricants. The incorporators are T. H. Meyer, F. C. Enz and E. H. Schmidt, Evansville.

THE SOUTHERN METAL WORKS, INC., Shelby, N. C., has been incorporated with a capital of $50,000, to manufacture babbitt metal, solders and kindred products. J. S. Williams is president, and Peyton McSwain, secretary and treasurer, both of Shelby.

THE SOAP & CHEMICAL MFG. CO., Secaucus, N. J., has been incorporated with a capital of $50,000, to manufacture chemicals and chemical byproducts, soaps, etc. The incorporators are Emerson C. McVausland, Charles W. Aschenbach and Percy Meebott, 210 Penhorn Ave., Secaucus.

THE UTILITY OIL CORP., Brooklyn, N. Y., has been incorporated with a capital of $100,000, to manufacture oil products. The incorporators are M. Slavin and S. Margolies. The company is represented by Schwimer & Gempler, 955 Broadway, Brooklyn.

THE RAINBOW OIL CO., Greenville, Miss., has been incorporated with a capital of $300,000, to manufacture petroleum products. The incorporators are A. R. Harbison and J. O. Barron, Hattiesburg, Miss.

THE GENERAL SEAMLESS TUBE CO., New York, N. Y., has been incorporated under Delaware laws with a capital of $1,450,000, to manufacture seamless steel tubing and kindred products. The incorporators are James W. Sanders, New York; H. Russ Van Vleck and William Hotchkin, Montclair, N. J. The company is represented by the United States Corporation Co., 65 Cedar St., New York.

THE OWENS REFINING CO., Cameron, Tex., has been incorporated with a capital of $45,000, to manufacture refined petroleum products. The incorporators are John S. Owens, John H. Edwards and E. A. Wallace, Cameron.

THE CHICAGO INSECTICIDE LABORATORY, INC., 3925 Calumet Ave., Chicago, Ill., has been incorporated under state laws with 10 shares of stock, no par value, to manufacture chemicals, insecticides, etc. The incorporators are A. J. Campbell, Albert and Benjamin Heller.

THE CAROLINA SMELTING & REFINING CO., Columbia, S. C., has been organized under state laws to operate a metal smelting and refining plant. A. Morgan is president, and N. Zalmenovitz, secretary-treasurer, both of Columbia.

THE M. C. O. OIL CO., San Francisco, Cal., has been incorporated with a capital of $2,000,000 under Delaware laws, to manufacture petroleum products. The incorporators are W. R. MacDonald and William H. Jordan, San Francisco. The company is represented by the Corporation Service Co., Wilmington, Del.

THE SHERWOOD PAPER CO., Boston, Mass., has been incorporated with a capital of $50,000, to manufacture paper specialties. Norman J. MacGaffin, West Medford, Mass., is treasurer.

Industrial Notes

THE QUIGLEY FURNACE SPECIALTIES CO., New York announces that it has added to its staff, as sales manager, Robert L. Warburton, who was formerly associated with the Celite Products Co.

W. LA COSTE NEILSON, heretofore foreign manager for the Norton Co., Worcester, Mass., at London, England, has been elected vice-president and general sales manager of the company. Other officials elected at a recent meeting are: Henry Duckworth as controller and assistant treasurer, Louis E. Saunders as head of the research department and John C. Spence as superintendent of the grinding machine division.

THE EXETER MACHINE WORKS, INC., West Pittston, Pa., makes the following announcements: The appointment of the English Tool & Supply Co. as exclusive sales agent for the Exeter rotary pump line in the Kansas City district; the appointment of Reeves & Skinner Machinery Co. of St. Louis, Mo., as sales agent in the St. Louis district; the appointment of the Hendrie & Bolthoff Mfg. & Supply Co. of Denver, Col., as sales agent in the Denver district; the appointment of the W. P. MacKenzie Co. as sales agent in the Philadelphia and Baltimore districts; the appointment of Buckmaster-Luck-Malochee, Inc., of New Orleans, Pa., as sales agent in the New Orleans district; the appointment of Vickers & Co. of Seattle, Wash., as sales agent in the Seattle district; the appointment of Hodgeart & Co. of Chicago, Ill., as sales agent in the Chicago district, and the H. M. Stark Machinery Co. of Detroit, Mich., as sales agent in the Detroit district.

Capital Increases, Etc.

THE BINNEY & SMITH CO., 81 Fulton St., New York, N. Y., manufacturer of lamp black, etc., has filed notice of increase in capital from $250,000 to $1,250,000.

THE VERNON COTTON OIL CO., Vernon, Tex., has filed notice of increase in capital from $250,000 to $300,000.

THE WESTERN PAPER BOX CO., 172 North Green St., Chicago, Ill., has filed notice of increase in capital from $35,000 to $100,000.

GODCHAUX SUGARS, INC., 527 Canal St., New Orleans, La., operating a number of sugar refineries, has arranged for a bond issue of $3,000,000. Charles Godchaux is president.

THE GRAND RAPIDS TIRE & RUBBER CORP., Grand Rapids, Mich., manufacturer of tires and rubber products, has filed notice of increase in capital from $3,000,000 to $9,000,000.

THE ROBERT GAIR CO., 350 Madison Ave., New York, manufacturer of paper boxes and other paper products, operating six large plants, has disposed of a bond issue totaling $4,000,000. George W. Gair is president.

THE TRANSCONTINENTAL OIL CO., 576 Fifth Ave., New York, N. Y., is arranging for a bond issue of $10,000,000, of which fund about $7,000,000 will be used for the purchase of new properties, extensions, expansion, etc.

J. G. Leavall has been appointed receiver for the GENERAL OIL CO., Houston, Tex., capitalized at $20,000,000. The company is said to be solvent but a receivership was deemed advisable.

THE EASTERN MFG. CO., Bangor, Me., operating paper and pulp mills, is arranging for a bond issue to total $2,500,000, for additional working capital.

Coming Meetings and Events

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE is holding its seventy-fourth meeting at Toronto, Canada, Dec. 26 to 31, 1921.

AMERICAN CERAMIC SOCIETY will hold its twenty-fourth annual meeting at St. Louis, Feb. 27 to March 2, 1922.

AMERICAN CHEMICAL SOCIETY will hold its spring meeting at Birmingham, Ala., April 4 to 7, 1922.

AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Baltimore, April 27, 28 and 29, 1922.

AMERICAN ENGINEERING COUNCIL will hold its next meeting in Washington, Jan. 5-6.

AMERICAN FOUNDRYMEN'S ASSOCIATION will hold its next convention and exhibit at Cleveland, O., during the week of April 24, 1922. Meetings will be held in the spring instead of in the fall as heretofore.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York the week of Feb. 20, 1922.

NEW JERSEY CHEMICAL SOCIETY holds a meeting at Stetters Restaurant, 842 Broad St., Newark, N. J., the second Monday of every month.

PERKIN MEDAL will be presented to William M. Burton by the Society of Chemical Industry at its meeting Jan. 13 at the Chemists' Club, New York.

STAMFORD CHEMICAL SOCIETY, Stamford, Conn., holds a meeting in the lecture room of the local high school on the fourth Monday of each month, except June, July, August and September.

The following meetings are scheduled to be held in Rumford Hall, the Chemists' Club, New York: Jan. 6—American Chemical Society, regular meeting; Jan. 13—Society of Chemical Industry, Perkin Medal; Feb. 10—American Electrochemical Society (in charge), Society of Chemical Industry, Société de Chimie Industrielle, American Chemical Society, joint meeting; March 10—American Chemical Society, Nichols Medal; March 24—Society of Chemical Industry, regular meeting; April 21—Society of Chemical Industry (in charge), American Electrochemical Society, Société de Chimie Industrielle, American Chemical Society, joint meeting; May 5—American Chemical Society, regular meeting; May 12—Société de Chimie Industrielle (in charge), American Chemical Society, Society of Chemical Industry, American Electrochemical Society, joint meeting; May 19—Society of Chemical Industry, regular meeting; June 9—American Chemical Society, regular meeting.

Volume 25, *No.* 26 December 28, 1921 *Pages* 1165-1204

CHEMICAL & METALLURGICAL ENGINEERING

H. C. PARMELEE, *Editor*

Contents

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Circulation of This Issue, 10,945

Filtering Syrup with SPERRY PRESSES

Annheuser-Busch, Inc., of St. Louis have recently installed ten Sperry Presses for filtering syrup and separating maltose mash.

Sperry Filter Presses have earned an enviable reputation for consistent service combined with minimum operating expense. They are used almost exclusively in modern plants throughout the country.

Twenty years from now these Sperry Presses will still be giving satisfactory service—long service life is one of the characteristics Sperry possesses.

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Our Filter Cloth Department is prepared to fill all your needs, either in sewed cloth or in rolls. Write today for prices.

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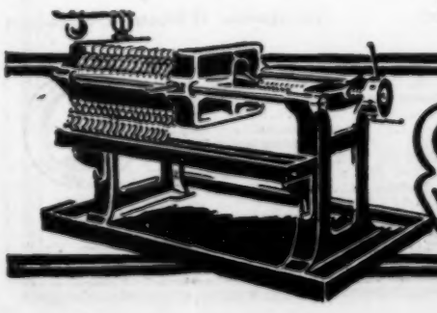

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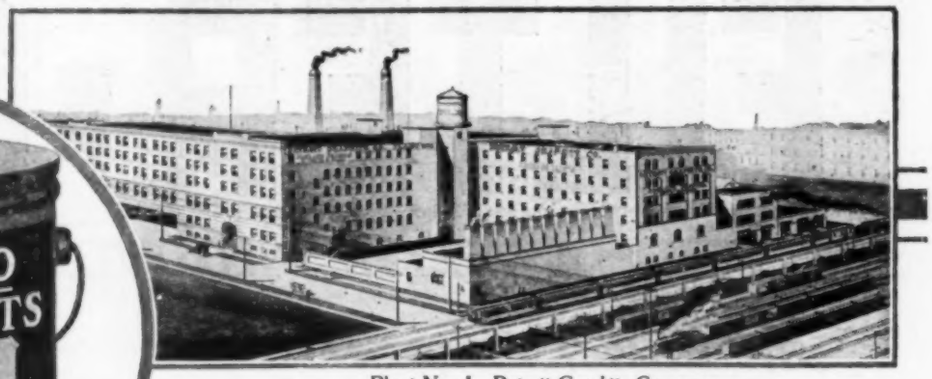

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DEGRACO PAINTS

Pronounced Dē-grā-kō Paints

For over thirty years we have manufactured and sold good paint. Today ***Degraco Paints*** are recognized as a standard signifying highest quality—maximum durability—lowest ultimate cost.

When you buy paint keep ***Degraco Paints*** in mind.

Superior Graphite Paint
For positive protection of structural steel and all metal surfaces. Prevents rust.

Degraco-Tone
An oil paint in flat finish for plaster walls, woodwork, wallboard, concrete, etc.

Degraco Concrete Coatings
For concrete, brick and masonry surfaces. Concrete Floor Paint.

Degraco Enamels
Machinery and Pipe Enamels. Finishes for all types of machinery and equipment.

Sta-White
Pure white, light-reflecting oil paint for plant interiors, power houses, storerooms, offices, etc.

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High quality paints for houses and industrial use, interior and exterior.

Degraco Damp-proof Paints
For damp-proofing and protecting surfaces exposed to water and moisture.

Degraco Stack Paint
Heat resisting formula for protection of stacks and other hot surfaces.

There is a Degraco Paint for every purpose

You are safe if you buy paint under the ***Degraco*** label. It is your assurance of satisfaction and true economy. We shall be glad to make recommendations covering your requirements.

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Sold through branch offices with warehouse stock in all principal cities

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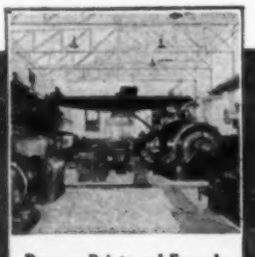
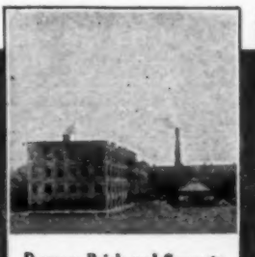
Sta-White—*a pure white, light-reflecting oil paint for industrial interiors. It stays white. The mill white you can rely upon.*

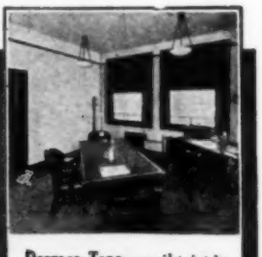
Superior Graphite Paint—*a protective coating for structural steel, bridges, metal roofs, stacks and all metal surfaces.*



Degraco Paints and Enamels *are made in all colors for use on interior and exterior surfaces, for every service requirement.*



Degraco Brick and Concrete Paints—*for interiors and exteriors. Concrete Walls, Floor Paint, Floor Hardener, Damp-proofing.*



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All Colors for All Purposes

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A Strong Conveyer for Very Large Capacities

This type of Jeffrey Standard Scraper Conveyer is fitted with either 30 x 10 or 36 x 10 inch steel scrapers to a steel cross bar which fastens in the flat link of the Flat and Round Steel Link Chain in which it can swivel, thus readily equalizing the load on two strands of chain.

The No. 518 Jeffrey Flat and Round Steel Link Chain used has a working strength of 5200 pounds.

This chain has the advantages of great wearing qualities in non-gritty and semi-gritty materials such as coal, due to the external and internal wearing surface of the flat link in addition to being a welded all-steel chain.

There's a type of Jeffrey Standard Scraper Conveyer adapted to your requirements. Get a copy of our complete Catalog No. 257-O

Jeffrey Number 518 Flat and Round Steel Link Chain fitted with 30 x 10 and 36 x 10 inch Scrapers spaced every 32 inches.

The Jeffrey Mfg. Co.

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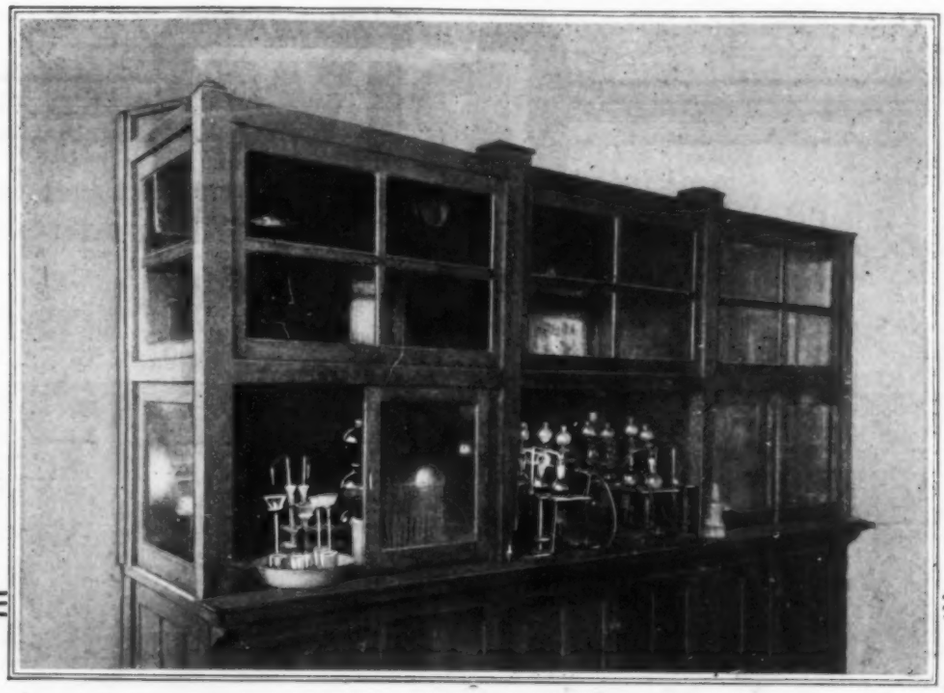

No finer testing ground to try out Ebony Wood than a hood-lining.

Its merit as a hood-lining suggests a thousand uses for Ebony Wood

STRUCTURAL materials that are chemically inert are scarce—where cost is a factor. This has hampered many processes, which Ebony Asbestos Wood now serves.

Why it is unusual

Ebony Wood resists acids.

It is not affected by water, oil or gases.

It will not crack under rapid and extreme temperature changes.

It is fireproof.

It has greater dielectric strength than marble or slate.

It lasts indefinitely.

Ebony Wood is made of asbestos fibre and binding cements impregnated under enormous pressure. But with all the mechanical strength and fireproofness of rock this remarkable material can be cut, sawed, nailed and fitted like ordinary lumber.

Useful all around the plant

These unique properties make Ebony Wood ideal for vents and ducts, for vats and containers, for laboratory table-tops, hood-linings and sinks.

Its mechanical and dielectric strength make it superior to slate and marble in the construction of switch-boards, panel-boards and bases for electrical appliances.

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and its allied products
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CHEMICAL AND METALLURGICAL ENGINEERING

Think "SEARCHLIGHT" First

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ADD 5 WORDS for box number in undisplayed ads if replies are to any of our offices. There is no extra charge for forwarding replies.

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8 to 14 in., $4.10 an in.	50 to 99 in., $3.70 an in.

POSITIONS VACANT

GRADUATE chemist wanted, general inorganic analyst. Middlewest. State concisely experience and salary expected. P-708, Chem. & Met. Engrg., Leader-News Bldg., Cleveland, Ohio.

EMPLOYMENT SERVICE

EXECUTIVES qualified for salaries of $2,500 to $25,000 and upward, are invited to communicate confidentially with the undersigned, who will conduct preliminary negotiations for such positions. A procedure is used which places you in the position of being approached, avoids jeopardizing present connections, and conforms to the most exacting personal and ethical requirements. Of particular advantage as a test of conditions, to determine the advisability of changing. Details mailed confidentially on receipt of name and address only, without obligating or committing you in any way. Established 1910. R. W. Bixby, Inc., 312 Lockwood Bldg., Buffalo, N. Y.

POSITIONS WANTED

BUSINESS man, educated as chemical engineer, but whose experience has been mostly commercial, will join technical man in new venture of merit, or will enter young, going concern, in sales or executive capacity; will invest money, experience and services. PW-638, Chem. & Met. Engrg., Leader-News Bldg., Cleveland, O.

CHEMICAL engineer, university graduate; age 26; with 4 years' experience laboratory and plant research; at present employed; desires position in plant. Not afraid of hard work where it means advancement. Initial salary no object. PW-654, Chem. & Met. Engrg., Real Estate Trust Bldg., Philadelphia, Pa.

CHEMICAL engineer, 1921 graduate, desires a position in Buffalo, or within commuting distance. Good references. PW-668, Chem. & Met. Engrg.

CHEMIST, college graduate Ph. B. 1912, with nine years' practical experience in general analytical, control, research and plant work, also metallurgical chemistry and metallography. PW-694, Chem. & Met. Engrg., Real Estate Trust Bldg., Phila., Pa.

POSITIONS WANTED

CHEMIST and chemical engineer with several years of practical experience along various lines (organic mainly), desires connection with reliable progressive concern in need of high class of service. Production, economics, improvements, plant management or any construction research. Value of service especially for coal tar and dyestuff industry. PW-690, Chem. & Met. Engrg.

CHEMIST, 1920 graduate; laboratory experience; desires position with future; initial salary and location secondary considerations. PW-707, Chem. & Met. Engrg.

CHIEF chemist and metallurgist, experienced zinc, manganese, steel works, drop forging, heat treatment. PW-710, Chem. & Met. Engrg., Old Colony Bldg., Chicago, Ill.

ELECTRO-metallurgical engineer, now employed, who has had charge of the designing, building and operating of successful, large electric furnaces for making various grades of steel, gray and malleable iron, and for the melting and refining of non-ferrous metals and for special metallurgical purposes, is desirous of securing position with large manufacturer who expects to make extensive use of electric furnaces in his business and design and build furnaces especially suited to his conditions. PW-706, Chem. & Met. Engrg.

EXPERIENCED chemist, university graduate; 10 years' experience in iron, steel and industrial laboratories; can take charge of your laboratory or assist in your research or manufacturing departments. PW-700, Chem. & Met. Engrg., Real Estate Trust Bldg., Phila., Pa.

INDUSTRIAL engineering, maintenance or construction. Ten years' supervision on maintenance and construction. Seven years' betterment work, on production organization, operation, appraisals and business administration. Age 35. PW-709, Chem. & Met. Engrg.

SALES and chemical engineer, technical graduates, three years' diversified experience. PW-704, Chem. & Met. Engrg.

POSITIONS WANTED

TECHNICAL graduate desires position as metallurgist or superintendent of heat-treating department. Has had six years' extensive experience in chemical and physical testing, and heat-treating of carbon and alloy steels in automobile and aeronautical motor plants. Best of reference. PW-643, Chem. & Met. Engrg.

TECHNICAL graduate, several years' experience in metallurgical plant management, operation and control, desires position as assistant to executive, superintendent or assistant superintendent of modern concern. Location immaterial. PW-655, Chem. & Met. Engrg.

WANTED

Wanted: Indicating Pyrometer

Up to 1200° C. with or without thermocouple. Analytical balance. W-705, Chem. & Met. Engrg.

BOOKS AND PERIODICALS

Chemical Magazines Wanted and For Sale

Chemical & Metallurgical Engineering, the American Chemical Society publications, London Journal, others, domestic and foreign. B. Login & Son, 152 East 23d Street, New York, N. Y.

FOR SALE

Black Steel Drums

5,000 new Whittaker-Glessner 110 gallon, No. 14 gauge; separate U-shaped rolling hoops shrunk on body; 2 inch bung in side no vent. Never been used, I. C. C. Specification No. 5. Seaboard By-Product Coke Co., Jersey City, N. J. Tel. Montgomery 4120.

Caustic Soda for Sale

In tank car lots. We can make you an exceptionally attractive proposition on a 37 per cent solution of guaranteed purity. No loss from N. Y. & L. tests and no troubles from dissolving or from rusty cans. FS-569, Chem. and Met. Engrg., Real Estate Trust Bldg., Phila.

WE WANT YOUR PLATINUM SCRAP

IN ANY FORM

We pay highest market price, make prompt returns and hold goods for your approval. Pure Gold, Silver and Platinum always on hand. Industrial Diamonds and Precious Stones Bought.

I. MILLER, *Smelter and Refiner*, 252 Colonial Arcade, Cleveland, Ohio

Chemists' Assistant

Young man wanted, either technical graduate or one who is attending a night course in chemistry, to assist in laboratory in factory. Answer stating age, past positions, if any, and salary expected to start.

P-703, Chem. & Metallurgical Engineering
10th Ave. at 36th St., New York City

EXECUTIVES

seeking positions find our confidential service extremely satisfactory. Let our Mr. H. H. Harrison confidentially negotiate for you suitable positions with proper employers, as he has successfully done for thousands of others since 1909. Inquiries invited.

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Confidential Negotiators
19 S. La Salle St., Chicago

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General Discussion on the Failure of Metals Under Internal and Prolonged Stress

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NOW READY

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of the General Discussion on

ELECTRODEPOSITION & ELECTROPLATING

held by the Faraday Society and the Sheffield Section of The Institute of Metals.

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WANTED

Chemical Engineer of sound scientific training and broad view of chemical and related industries. Good judgment requisite for passing on contributions. Plant experience desirable.

Mechanical engineer who has had experience in the construction and operation of chemical and industrial plants, and who is familiar with methods of handling materials. Work mainly in the field.

The ability to write good English is essential in both of these positions. Personality, initiative and accuracy are important qualifications. In applying please state age, training, experience and salary desired.

P-684 Chem. & Met. Engineering
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Chemical Machinery

NEW—UNUSED

2—Buflokast Crystallizers, 6-ft. diameter.
2—275-gal. Autoclaves.
1—Wooden Filter Press, 12 in. x 12 in.
1—Patterson Pebble Mill, 3 ft. x 4 ft.
1—Rotary Cutter No. 2.
1—Zaremba Triple Effect Evaporator.
1—Raymond 8-ft. Dust Collector.
2—Alberger 1-gal. Autoclaves.

USED—REBUILT

5—Wooden Filter Presses, 30 x 30, 36 x 36, 42 x 42.
3—Iron Filter Presses, 24 x 24, 30 x 30.
2—Sweetland Filter No. 2; 9.
3—Kelley Filters, 150, 450, 850.
1—Oliver Rotary Filter, 6 ft. x 6 ft.
1—Devine Vacuum Drum Dryer, 40 in. x 60 in.
2—Buffalo Drum Dryers, 5 ft. x 12 ft.
1—Buffalo Rotary Vacuum Dryer, 5 ft. x 30 ft.
1—Buffalo Sulphonator, 300 gals.
2—Valley Sulphonators, 500, 750 gals.
1—Hardinge Conical Mill, 8 ft. x 22 in.
3—Abbe Pebble Mills No. 6.
2—Allis-Chalmers Tube Mills, 4 ft. 6 in. x 12 ft.
1—Raymond Pulverizer, No. 0; complete.
1—Day Universal Mixer No. 3; jacketed.
1—Day Imperial No. 40; jacketed.
3—Sturtevant Rotary Crushers, No. 0, 00, 1.
2—Extractors, 30-in. steel basket.

Send us your inquiries

Alberger Chemical Machinery Co., Inc.
Grand Central Palace, New York
Vanderbilt 2971

Flotation Blowers

28—Connersville Blowers. Double outboard bearing. Capacity, 24.5 cu.-ft. per revolution, 3,200 cu.-ft. per minute at 255 r.p.m. Maximum pressure, 4.58 lb. per sq. in. at 255 r.p.m.

7—Roots Style D High Pressure Type Blowers. Capacity, 890 cu.-ft. per minute at 435 r.p.m. Maximum pressure, 9 lb. per sq. in. at 435 r.p.m.

These blowers were purchased for the Old Hickory Powder plant. Some were never installed and others were used less than 90 days. Practically new machines at used prices.

Nashville Industrial Corporation
Jacksonville, Tenn.

Chemical Ware and Machinery

From the Old Hickory Powder Plant. An immense amount of new and slightly used chemical stoneware, duriron, laboratory equipment, technical machinery, boilers, engines, etc., now available for immediate delivery at extremely low prices.

Write for Bulletin No. 14

Nashville Industrial Corporation
Jacksonville, Tenn.

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the equipment or machinery that you are not using. This may be occupying valuable space, collecting dust, rust and hard knocks in your shops and yards.

SELL IT BEFORE DEPRECIATION SCRAPS IT

The Searchlight Section is Helping Others

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"Opportunity" Advertising:

Think
"SEARCHLIGHT"
First!

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CHEMICAL EQUIPMENT

AUTOCLAVES

3—C.I., 33 x 42 in., 155 gal.; 54 x 42 in., 250 gal. 54 x 60 in, 327 gal.

CENTRIFUGES

2—Schaum & Ulinger Basket, 30 x 15 in.; machine 46 x 66 in., belt drive.

EXTRACTORS

1—Hydro, 48 in. dia., bottom drive.

FILTER PRESSES

4—Hagstrom Presses, 42 x 42 in., capacity 36 plates and frames.
1—Sweetland Experimental Press, 3 x 2 ft. x 10 in., laboratory size.
1—C.I. Suction Filter, porcelain lined, 32 x 38 in.

KETTLES

2—Fusion C.I., 5 ft. 6 in. x 4 ft. 2 in., 600 gal.; 3 ft. 6 in. x 3 ft. 2 in.
1—Filter, C.I., 3 x 2 ft., 17 ½ gal.
1—Elyria No. 2028 Dopp steam jacketed, 3 ft. 11 in. x 2 ft. 2 in., 195 gal.
3—C.I., 3 x 3 ft.; 3 x 2 ft. 6 in.; 3 x 2 ft.
1—C.I. Evaporating, 7 x 2 ft., steam jacketed.

LABORATORY EQUIPMENT

1—Buffalo Blower, Emerson, 10 x 10 x 5 ¼ in., with 1/10th hp. Emerson motor.
1—Grinder, Mange & White, 18 x 17 in.
2—Autoclaves, experimental, 3 ½ x 6 ½ in.

MILLS

1—Abbe Ball, 5 x 4 ft., with 60-in. gear.
1—Grinder Mill, Ross, 18-in. mill, belt drive

MIXERS

1—C.I. Drum, Townsend, 35 x 45 in., 110 gal. horizontal.
1—Steam Jacketed, Universal, 6 x 11 x 11 in., 2 lbs.

MONTJUS

1—Stevens Alysworth, 3 x 8 ft., 450 gal.
2—No markings.

PUMPS

1—Burnham, 8 ½ x 5 ½ x 10 in.
1—Goulds, Triple, 7-in. piston, 8-in. stroke, 200 gal.
1—Volute, Alberger, 4 in., 14-in. head, 500 gal.
1—Centrifugal, Fairbanks, 2 x 1 ½ in.
2—Marsh Boiler Feed, American No. 149572, No. 149077, 18 x 24 in.
1—Viking, No. 8214, 3 ½ x 4 in.
2—Gould, centrifugal, No. 85556, No. 85557, 24 x 14 x 15 in.
1—Magna, Deane, 6 in. x 4 ft. x 12 in., horizontal
1—Brackner rotary, No. 33132, Cyl. 3 in. x 4 in., shaft ½ x 11 in.
1—Worthington, 5 ½ x 3 ½ x 5 in.
2—Deane, No. 83217, No. 83724, 7 ½ x 5 x 6 in.
3—Monkey Pumps, 17 x 16 ½ in., one 1-gal. two 2-gal.
1—Centrifugal, Worthington, Style 5, Class D. 30 x 60 x 32 in., diam. 28 in.
1—Centrifugal, Keystone, 26 x 46 x 45 in.
1—Steam, American, No. 127995, 5 x 8 x 10 in.
1—Steam, Knowles, 6 ½ x 8 x 15 x 12 in.
1—Vacuum, Gould & Garrison, No. 25347, length 28 x 60 in., cyl. 8 x 12 in.
1—Steam, Deane, No. 83300, 7 ½ x 5 x 6 in.
1—Dry Vacuum, Devine, No. 1012, 6 ft. 6 in. x 32 in.

SCALES

8—Platform, 200 to 2500 lb. cap.

STILLS

2—C.I., steam jacketed, Quaker City, 3 x 4 ft., 240 gal., working pressure of still shell, 100 lb., jacket, 125 lb.
1—Steel, lead lined, 76 x 60 in., 1000 gal., with lead coil and agitator.
1—Enameled, Elyria, 3 x 2 ft., 35 gal., steam jacketed.

SULPHONATORS

1—4 ft. 6 in. x 5 ft., no markings.
1—C.I. Valley Iron Works, 3 ft. 6 in. x 3 ft. 6 in. 252 gal.

TANKS

1—G.I., 5 x 5 ft., 735 gal., with spiral coil.
2—Steel, 24 x 30 in., 59 gal., no agitator.
1—Steel, cylindrical, no agitator.
1—Steel, receiving, jacketed, 36x 36 in., no agitator.
28—Cypress Wooden Tanks, 500 to 9500 gal.

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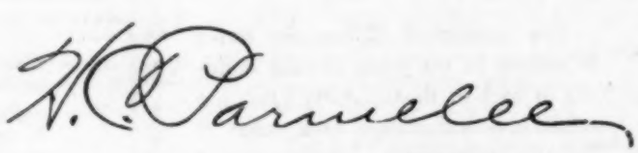

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Perry & Webster
Phila. Drying Mach. Co.
Proctor & Schwartz, Inc.
Sleeper & Co., O.
Vulcan Iron Works

Duriron, Acid Proof, Mild
Duriron Co.

Dust Collecting Systems
Allis-Chalmers Mfg. Co.
Raymond Bros. Imp. P. Co.
Research Corp.
York Heating & Ventilating Corpn.

Dynamos and Motors
Jantz & Leist Elect. Co.

Ejectors or Steam Syphons
Duriron Co.

Electric Furnace Tubes, Alundum
Norton Co.

Electrical Appliances
Johns-Manville, Inc.

Electrical Precipitators
Research Corp.

Electrical Testing Sets
American Transformer Co.

Electrolytic Cells
Electron Chem. Co.
Warner Chemical Co.

Electroplating Dynamos; Supplies
Jants & Leist Elect. Co.

Electroplating Salts
Roessler & Hasslacher Chem. Co.

Enameled Apparatus, Acid Resisting
Elyria Enameled Prod. Co.

Engineers, Chemical, Consulting, Analytical, Industrial
See Prof. Direc.
Amer. Ind. Furnace Corp.
Chase, Frank D.
Dorr Co., The
Fleisher & Co., W. L.
Guarantee Cons. Co.

Engineers, Combustion
Combustion Engr. Corp.

Engineers, Construction
Chase, Frank D.
Chemical Construction Co.
Guarantee Cons. Co.

Engineers, Furnace
Amer. Ind. Furnace Corp.
Hagan, Geo. J., Co.

Engines, Gas and Gasoline
Fairbanks, Morse & Co.

Engines, Oil
Fairbanks, Morse & Co.
Ingersoll-Rand Co.

Engines, Steam and Hauling
Vulcan Iron Works

Evaporating Dishes
Thermal Syndicate, Ltd.

Evaporators
Allbright-Nell Co.
Baker Sons & Perkins Co.
Buffalo Fdy. & Mach. Co.
Devine Co., J. P.
Knight, Maurice A.
Koven, L. O., & Bro.
Lancaster Iron Works.
Sperry, D. R., & Co.
Zaremba Co.

Exhausters, Rotary Positive Gas
Connersville Blower Co.

Extractors
Buffalo Fdy. & Mach. Co.
Devine Co., J. P.
Koven, L. O. & Bro.

Extractors, Centrifugal
Tolhurst Machine Works

Fans
Buffalo Forge Co.
Phila. Drying Mchy. Co.
Proctor & Schwartz, Inc.
Raymond Bros. Imp. P. Co.
Vulcan Iron Works

Fans, Acid Proof
Duriron Co.

Fans, Stoneware, Acid Proof
Knight, Maurice A

Feeders
Jeffrey Mfg. Co., The
Hardinge Co.

Felts, Paper Makers
Huyck Co., F. C.

Ferro-Alloys
Standard Alloys Co.
Titanium Alloy Mfg. Co.

Fibre Conduit and Fibre Products
Johns-Manville, Inc.

Filter Cloth
Huyck Co., F. C.

Filter Cloth, Metallic
Ludlow-Saylor Wire Co.

Filter, Fibre, Gooch
Powhatan Mining Co.

Filter Media
Powhatan Mining Co.

Filter Paper
Angel & Co., H. Reeve

Filter, Porous Porcelain
Coors Porcelain Co.

Filter Presses
Allbright-Nell Co.
Colorado Iron Wks. Co.
Industrial Filtration Corp.
Koven, L. O., & Bro.
Oliver Continuous Filter Co.
Patterson Fdy. & Mach. Co.
Perrin & Co., W. R.
Shriver, T., & Co.
Sperry, D. R., & Co.
United Filters Corp.
Valles, H. A.

Filtering Materials
Celite Products Co.

Filter, Cloth, Metallic
Newark Wire Cloth Co.

Filters, Air
Research Corp.

Filters, Rotary Continuous
Colorado Iron Wks. Co.
General Filtration Co.
Industrial Filtration Co.
Oliver Continuous Filter Co.

Filters, Suction, Stoneware Acid Proof
General Ceramics Co.

Filters, Water
Hungerford & Terry

Fire Extinguishers
Johns-Manville, Inc.

Firesand, Crystolon
Norton Co.

Flooring, Industrial
Johns-Manville, Inc.

Flotation Apparatus
Colorado Iron Wks. Co.

Furnace Facings and Linings
Crescent Refractories Co.

Furnaces, Assay
Braun Corp.
Braun-Knecht-Heimann-Co.
Denver Fire Clay Co., The

Furnaces, Brass or Aluminum Melting
Chicago Flexible Shaft Co.
Detroit Electric Furnace Co.

Furnaces, Electric
Amer. Ind. Furnace Corp.
Detroit Elec. Furnace Co.
Leavitt, C. W., & Co.

Furnaces, Electric, Lab'y
Eimer & Amend
Hoskins Mfg. Co.

Furnaces, Heat Treating
Amer. Ind. Furnace Corp.
Chicago Flexible Shaft Co.
Electric Furnace Cons. Co.
Hagan, Geo. J., Co.
Hoskins Mfg. Co.
Lancaster Iron Works

Furnaces, Muffle
Chicago Flexible Shaft Co.
Hoskins Mfg. Co.

Furnaces, Porcelain Enameling.
Chicago Flexible Shaft Co.

Furnaces, Roasting & Smelt'g
Allis-Chalmers Mfg. Co.
Colorado Iron Wks. Co.
Pacific Fdy. Co.

Fused Silica
Chapman Eng. Corp.
General Ceramics Co.
Thermal Syndicate, Ltd.

Gas Producers
Flinn & Dreffein Co.
Morgan Construction Co.

Gas Pumps, Rotary Positive
Roots Co., P. H. & F. M.

Gauge Boards
Foxboro Co.

Gauges, Liquid Level
Foxboro Co.

Gauges, Recording, Indicating, Draft, Pressure
Bailey Meter Co.
Bristol Co., The
Foxboro Co., The
Pneumercator Co.
Schaeffer & Badenberg Mfg. Co.
Taylor Instrument Co.

Gears
Caldwell H. W., & Son Co.
Jeffrey Mfg. Co.

Gears, Compensation
Morse Chain Co.

Glass Blowing
Eimer & Amend
Braun-Knecht-Heimann-Co.

Glassware, Chemical
Braun Corp.
Braun-Knecht-Heimann-Co.
Eimer & Amend
Kauffman-Lattimer Co.
Kimble Glass Co.
Schaar & Co.
Will Corporation, The

Glue, Fireproof
Johns-Manville, Inc.

Graphite
Detroit Graphite Co.

Grates
Combustion Engr. Corp.

Grinders, Ore
Hardinge Co.

Heat Exchange App.
Whitlock Coil Pipe Co.

Heaters, Feed Water
Whitlock Coil Pipe Co.

Heating App. and Systems
American Blower Co.
Atmospheric Cond. Corp.
Fleisher & Co., W. L.
Parks-Cramer Co.
Powers Regulator Co.

Heating Regulators
Powers Regulator Co.

Heat Insulation
Celite Products Co.

Hoists
Fairbanks, Morse & Co.

Hoists, Portable
Ingersoll-Rand Co.

Hose
Ingersoll-Rand Co.

Hot Water Storage Heaters
Whitlock Coil Pipe Co.

Hydro-Extractors
Tolhurst Machine Wks.

Hydraulic Machinery
Oilgear Co.

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Eimer & Amend
Gaertner & Co., Wm.
Pneumercator Co.
Stupakoff Laboratories
Valley Iron Works

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Celite Products Co.

Insulation, Asbestos and Magnesia
Johns-Manville, Inc.

Jackets, Paper Makers
Huyck Co., F. C.

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International Cooperage Co.

Kegs, Wooden
International Cooperage Co.

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Duriron Co.

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Buffalo Fdry. & Mach. Co.
Devine Co., J. P.
Valley Iron Works

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Elyria Enameled Prod. Co.

Kettles, Steam-Jacketed
Baker Sons & Perkins Co.
Bethlehem Fy. & Mch. Corp.
Buffalo Fdry. & Mach. Co.
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Maxon Furnace & Eng. Co.
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American Process Co.
Vulcan Iron Works

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Duriron Co.

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Baker Sons & Perkins Co.
Braun Corp.
Braun-Knecht-Heimann Co.
Daigger, A., & Co.
Denver Fire Clay Co.
Eimer & Amend
Gaertner & Co., Wm.
Heil Chemical Co., Henry
Hoskins Mfg. Co.
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Schaar & Co.
Tolhurst Mach. Works
Will Corporation, The

Laboratory Ware, Boats, Crucibles, Thimbles, Alundum
Norton Co.

Lead Burning
Abernethy, J. F.

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Lehigh Lime Co.

Lifts, Air Jet
Bethlehem Fy. & Mch. Corp.

Loaders, Wagon and Truck
Barber-Greene Co.

Locomotives, Industrial
Jeffrey Mfg. Co.
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Baker Sons & Perkins Co.
Bethlehem Fy. & Mch. Corp.
Caldwell, W. E., & Co.
Dorr Co., The
New Eng. Tank & Tower Co.

Machinery, Auto Weighing
Baker Sons & Perkins Co.
Pneumercator Co.
Schaffer Eng. & Equip. Co.

Machinery, Coal Grinding
Jeffrey Mfg. Co.
Raymond Bros. Imp. Pul. Co.

Machinery, Conveying and Elevating
Bartlett & Snow Co.
Caldwell, H. W., & Son Co.
Jeffrey Mfg. Co.
Valley Iron Works

Machinery, Crushing, Grinding and Pulverizing
American Pulverizer Co.
Colorado Iron Wks. Co.
Fuller-Lehigh Co.
Jeffrey Mfg. Co.
Kent Mill Co.
Patterson Fdy. & Mach. Co.
Raymond Bros. Imp. Pul. Co
Thomas, A. H., Co.
Vulcan Iron Works

Machinery, Crushing, Grinding and Pulverizing (Lab.)
Braun Corp.
Braun-Knecht-Heimann-Co.
Jeffrey Mfg. Co.

Machinery, Cyanide
Colorado Iron Wks. Co.
Dorr Co., The

Machinery, Dewatering
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New Eng. Tank & Tower Co.

Machinery, Ore and Coal Handling
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Machinery, Ore Concentrating
Dorr Co., The
Kent Mill Co.

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Vogt, Henry, Machine Co.
York Mfg. Co.

Machinery, Special
Baker Sons & Perkins Co.
Bethlehem Fdy. & Mach. Co.

Machinery, Thickening & Dewatering
Dorr Co., The

Machinery, Transmission
Morse Chain Co.

Machinery, Turbine
De Laval Steam Turbine Co.

Machinery, Weighing
Baker Sons & Perkins Co.
Pneumercator Co.
Schaffer Eng. & Equip. Co.

Magnesia, Alundum, Crystolon
Norton Co.

Magnesium Metal
Leavitt, C. W., & Co.

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Dings Magnetic Separator Co.

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Central Steel Co.

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Meters, Coal, Feed Water, Steam
Bailey Meter Co.

Meters, Flow, Air, Gas, Water
Bailey Meter Co.
Spray Eng. Co.

Mills, Ball, Pebble & Tube
Patterson Fdy. & Mach. Co.

Mixers, Batch
Baker Sons & Perkins Co.

Motors, Electric
Fairbanks, Morse & Co.

Muriatic Acid Plants, Stoneware Acid Proof
General Ceramics Co.

Nitrating Kettles, Stoneware Acid Proof
Knight, Maurice A.

Nitrators, Centrifugal
Tolhurst Mach. Works

Nitric Acid Plants
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Duriron Co.

Nozzles, Spray
American Blower Co.
Buffalo team Pump Co.
Duriron Co.
Spray Eng. Co.

Oil and Grease Extraction Equip.
Bartlett & Snow Co.

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Paints, Pigment Graphite
Detroit Graphite Co.

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Pans, Vacuum
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Buffalo Fdry. & Mach. Co.
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Crane Co.
Pacific Fdy. Co.

Pipe and Fittings, Lead, Tin or Silver Lined
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Michigan Pipe Co.
National Tank & Pipe Co.
Pacific Tank & Pipe Co.
Stearns Lumber Co., A. T.
United Lead Co.

Pipe, Silica Ware
Kastenhuber & Lehrfeld Co.
Thermal Syndicate, Ltd.

Pipe, Steel, Riveted
Petroleum Iron Wks.

Plates, Tank Steel
Ryerson & Son

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Bishop, J. & Co., Plat. Wks.
Kastenhuber & Lehrfeld

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Duriron Co.

Pots, Cast Iron, Acid Proof
Baker Sons & Perkins Co.
Bethlehem Fdy. & Mach Co.
Duriron Co.

Pots, Stoneware, Acid Proof
Acid Proof Clay Prod. Co
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Lummus Co., The W. E.
owers Regulator Co.

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American Steam

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Oilgear Co.

Pulleys, Cast Iron
Jones Fdy. & M

Pulley, Magnetic
Dings Magnetic Co.

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American Well
Duriron Co.
Nash Eng. Co.
United Lead Co.

Pumps, Boiler Fe
Amer. Steam P
Devine Co., J. P
Fairbanks, Mors

Pumps, Brine
Ingersoll-Rand C

Pumps, Centrifug
Amer. Steam P
Amer. Well Wor
Fairbanks, Mors
Ingersoll-Rand C
LaBour Co.
Taber Pump Co

Pumps, Diaphrag
Ingersoll-Rand C

Pumps, Fire
Amer. Well Wor

Pumps, Gas or L
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Amer. Well Wor
Ingersoll-Rand

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Ingersoll-Rand C

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Connersville Blo
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Schaeffer & Bud
Co.
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Taylor Instrume

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Foxboro Co., Th
Schaeffer & Bud
Co.

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Crane Co.

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Retorts, Vertical
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Rodium
Kastenhuber & Lehrfeld

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Jeffrey Mfg. Co.

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Baker Sons & Perkins Co.
Fairbanks, Morse & Co.
Schaffer Eng. & Equip. Co.

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Cleveland Wire Cloth & Mfg Co.
Newark Wire Cloth Co.
Patterson Fdy & Mach. Co.

Screens, or Cloth, Fertilizer
Ludlow-Saylor Wire Co.

Screens, Mining
Ludlow-Saylor Wire Co.

Screens, Wire, Brass, Cu. Steel
Ludlow-Saylor Wire Co.

Second and Equipment
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Separators, Air
Raymond Bros. Imp. P. Co.

Separators, Centrifugal
American Tool & Mach. Co.
Tolhurst Mach. Works

Separators, Magnetic
Dings Magnetic Separator Co.o

Separators, Gas
Petroleum Iron Wks.

Sieves, Laboratory
Newark Wire Cloth Co.

Sinks and Trap, Lab. Stoneware
Knight, Maurice A.

Spectrometers
Gaertner & Co., Wm.

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Spray Eng. Co.

Sprockets
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Sprockets, Wheels and Chain
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Sprockets, Compensating
Morse Chain Co.

Sprockets, Silent Chain
Morse Chain Co.

Stacks, Smoke, Steel
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Central Steel Co.
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Central Steel Co.
Standards Alloys Co.

Steel Plate Construction
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Hammond Iron Works
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Youngstown Boiler & Tank Co.

Steel Sheets, Siding, Roofing
Central Steel Co.
Ryerson & Son

Steel, Structural
Pittsburgh-Des Moines
Ryerson, Jos. T., & Son Co.
Steel Co.
Central Steel Co.

Stills, Heating
Power Specialty Co.

Stills, Oil, Tar, etc.
Petroleum Iron Wks.
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Stirrers, Acid Proof
Duriron Co

Stokers
Babcock & Wilcox Co.
Combustion Engr. Corpn.
Hagan, Geo. J. Co.

Stoneware, Chemical, A. P.
Acid Proof Clay Prod. Co.
Knight, Maurice A
U. S. Stoneware Co.

Stopper Heads
Bartley, J., Crucible Co.

Sulphur
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Sulphuric Acid Plants
Chemical Construction Co.

Superheaters
Babcock & Wilcox Co.
Power Specialty Co.

Syphons, Acid, Stoneware
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Lancaster Iron Works
Petroleum Iron Wks.
Sharpsville Boiler Works

Tanks, Acid Proof
Duriron Co.

Tanks, Cyanide
Pacific Tank & Pipe Co.

Tanks, Lead Lined
Abernethy, J. F.
Chemical Cons. Co.
United Lead Co.

Tanks, Steel, Pressure and Storage
Caldwell Co., W. E.
Graver Corp.
Hammond Iron Works
Lancaster Iron Works
Petroleum Iron Wks.
Sharpsville Boiler Works
Youngstown Boiler & Tank Co.

Tanks or Vats, Stoneware A. P.
U. S. Stoneware Co.

Tanks, Wood
Caldwell Co., W. E.
Chemical Construction Co.
Hauser-Stander Tank Co.
Kalamazoo Tank & Silo Co.
National Tank & Pipe Co.
New Eng. Tank & Tower Co.
Pacific Tank & Pipe Co.
Stearns Lumber Co., A. T.
Woolford Wood Tank Mfg. Co.

Thermometers, Recording and Indicating
Bristol Co., The
Taylor Instrument Co.

Thermometers, Recording Flue Gas
Bailey Meter Co.

Tile, Acid Proof
Knight, Maurice A.

Titanium
Titanium Alloy Mfg. Co.

Titanium Ores
Titanium Alloy Mfg. Co.

Tool Steel
Standard Alloys Co.

Tower Packing, Stoneware
U. S. Stoneware Co.

Towers, Acid
Duriron Co.

Towers, Acid, Wood
Hauser-Stander Tank Co.

Towers, Condensing or Absorbing, Stoneware, A. P.
General Ceramics Co.
Knight, Maurice A.

Towers, Steel
New Eng. Tank & Tower Co.

Towers, Water Cooling
Wheeler, C. H., Mfg. Co.

Track Work, Narrow Gauge
Easton Car & Cons. Co.

Transformers
Allis-Chalmers Mfg. Co.
Amer. Transformer Co.

Transformers, Special and Precipitation Process
Amer. Transformer Co.

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Morse Chain Co.

Transmission; Variable Speed
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Ingersoll-Rand Company

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Crane Co.
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Duriron Co.

Vats, Wood
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Pacific Tank & Pipe Co.
Stearns Lumber Co., A. T.
Woolford Wood Tank Mfg. Co., G.

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Bayley Mfg. Co.

Water Purification, Rectification and Softening
Graver Corp.
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Water Tube Boilers
Babcock & Wilcox Co.

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Blaw-Knox Co.

Whizzers
Tolhurst Mach. Works

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